DOCUMENT RESUME

ED 212 803	CE 031 197
TITLE	Wheeled Vehicle Steering Systems. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Army Ordnance Center and School, Aberdeen Proving Ground, Md.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Vocational and Adult Education (ED), Washington, D.C.
PUB DATE	[81]
NOTE	241p.; For related documents see CE 031 194-196.
EDRS PRICE	MF01/PC10 Plus Postage.
DESCRIPTORS	*Auto Mechanics; Correspondence Study; Engines; Experiential Learning; Independent Study; Inservice Education; Job Training; Learning Modules; *Military Training; *Motor Vehicles; Postsecondary Education; *Repair; Secondary Education; *Technical Education; Vocational Education
IDENTIFIERS	Military Curriculum Project; *Steering (Automotive)

ABSTRACT

This course is one of several subcourses that make up the entire Army correspondence course on wheeled vehicle maintenance. The subcourse is designed to provide the student with information about the operation, malfunction diagnosis, maintenance, and repair of wheeled vehicle steering systems. It provides the basic theory, and also includes on-the-job task assignments. The subcourse is divided into five lessons covering the following topics: fundamentals of hydraulics; introduction to wheeled steering systems; maintenance of mechanical steering gear assemblies; maintenance of power steering gears; and maintenance of steering linkages. Each lesson contains objectives, text, task assignments, and review exercises. Answers for the exercises are provided after the final lesson, along with an examination and application task test. This subcourse is designed for student self-study, but could be used in small group learning situations. (KC)

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ED212803

Military Curriculum Materials for Vocational and Technical Education

WHEELED VEHICLE STEERING SYSTEMS

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY
1960 KENNY ROAD · COLUMBUS, OHIO 43210

CE031197

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
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The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

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- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

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Military Curriculum Materials
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Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

Agriculture
Aviation
Building & Construction Trades
Clerical Occupations
Communications
Drafting
Electronics
Engine Mechanics
Food Service
Health
Heating & Air Conditioning
Machine Shop
Management & Supervision
Meteorology & Navigation
Photography
Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

SCHOOL CODE
091

SUBCOURSE HB6307
ED 5

U.S. Army Training Support Center

Fort Eustis, Virginia

ACCP

WHEELED VEHICLE STEERING SYSTEMS

ARMY CORRESPONDENCE COURSE PROGRAM

IMPORTANT: READ AND POST

Lesson Change 1
26 January 1976

Ordnance Subcourse 63B207
Wheeled Vehicle Steering System
October 1975

Lesson 5, Page 5-30, Para 10d, Line 1. Change to read:

c. The relay . . .

EXERCISE RESPONSE LIST

Page 1, Response Number 123. Change to read:

543 Para 4a

Page 12, Response Number 502. Change to read:

654 CORRECT. This would have . . .

IMPORTANT: READ AND POST

WHEELED VEHICLE STEERING SYSTEMS
63B207

Correspondence Course 8-16

Developed by:

United States Army

Development and Review Dates:

October 1975

Occupational Area:

Engine Mechanics

Print Pages:

234

Availability:

ERIC
National Center Clearinghouse

Suggested Background:

None

Target Audiences:

Grade 10-Adult

Organization of Materials:

Text, Objectives, Exercises, Examination

Type of Instruction:

Individualized

Type of Materials:	No. of Pages:	Average Completion Time:
Lesson 1 - Fundamentals of Hydraulics	38	2 Hours
Lesson 2 - Introduction to Wheeled Vehicle Steering Systems	42	3 Hours
Lesson 3 - Maintenance of Mechanized Steering Gear Assemblies	33	2 Hours
Lesson 4 - Maintenance of Power Steering Gears	47	2 Hours
Lesson 5 - Maintenance of Steering Linkages	43	3 Hours
Exercise Response List	28	

Supplementary Materials Required:

None

1A

Course Description:

This course is one of several subcourses that make up the entire correspondence course on wheeled vehicle maintenance. The subcourse is designed to provide the student with information about the operation, malfunction diagnosis, maintenance, and repair of wheeled vehicle steering systems. It provides the basic theory, and also includes on-the-job task assignments.

The subcourse is divided into five lessons with objectives, task assignments, and review exercises.

Lesson 1 - Fundamentals of Hydraulics. A study of basic principles of fluids under pressure, the means by which hydraulics can be used to multiply force, and the construction and operation of hydraulic system components.

Lesson 2 - Introduction to Wheeled Vehicle Steering Systems. An explanation of the construction and operation of mechanical and power steering gears and steering linkages; also, the principles of steering geometry.

Lesson 3 - Maintenance of Mechanical Steering Gear Assemblies. A description of the procedures used for the inspection, testing, adjustment, and repair of mechanical steering gears; the removal and installation of assemblies; and the replacement of repair parts.

Lesson 4 - Maintenance of Power Steering Gears. The inspection, testing, adjustment, and repair of power steering gears and their associated hydraulic equipment; removal and installation of assemblies; and the replacement of repair parts.

Lesson 5 - Maintenance of Steering Linkages. The inspection, testing, adjustment, and repair of steering linkage components; the replacement of repair parts; front-wheel alinement procedures; and troubleshooting steering systems.

This subcourse is designed for student self-study, but could be effective in small group learning situations. Each lesson contains objectives, text, and review exercises. Answers for the exercises are provided after the final lesson, along with an examination and application task test.

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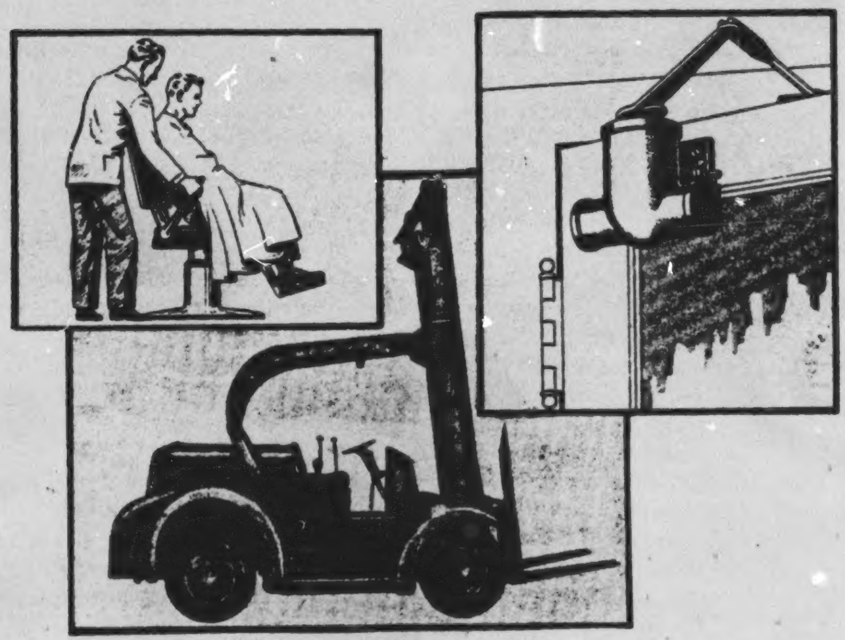
3.

ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B207
WHEELED VEHICLE STEERING SYSTEMS



LESSON 1
FUNDAMENTALS OF HYDRAULICS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

4

-- IMPORTANT --

STUDY THIS SHEET

before beginning the subcourse

General

Your cooperation in following these instructions will

--enable you to make the maximum rating commensurate with your ability.
--help us to process your lessons promptly and efficiently.

Scan the CHECKLIST OF TEXTS AND MATERIALS FURNISHED.
Scan the INTRODUCTION to the subcourse.

Procedure

--Beginning with Lesson 1, scan the LESSON ASSIGNMENT SHEET. It lists the lesson title, lesson objective, credit hours required, texts required, and suggestions.
--When the words STUDY TEXT follow the Lesson Assignment Sheet, the information you must digest is found in a text(s), memorandum, pamphlet, and/or other separate material(s).
--When the words STUDY GUIDE AND ATTACHED MEMORANDUM follow the Lesson Assignment Sheet, the information you must digest is either
  --found in texts and in this subcourse booklet, or
  --found entirely in this booklet.
--When you are referred to a paragraph or an illustration in a manual, turn to the specified paragraph at once and scan or study the text assignment as directed. Continue this procedure until you reach the LESSON EXERCISE.

Lesson Exercise

--Study and answer each question.
--CAUTION: Check to insure that all questions have been answered.
--Your answers MUST be based on subcourse materials, NOT on your experience or opinions.

Assistance

If you require explanation or clarification of subcourse materials or questions, write to the U. S. Army Ordnance Center and School, ATTN: Department of Army Wide Training Support. Constructive comments are appreciated.

Include NAME and SOCIAL SECURITY ACCOUNT NUMBER on all correspondence.

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LESSON EXERCISE QUESTIONS

Instructions for use of the answer sheet:

1. The procedure by which you will answer the exercise questions in this subcourse is probably new to you. The information is presented in a programed instruction format where you immediately know whether or not you have answered the questions correctly. If you have selected an incorrect answer, you will be directed to a portion of the study text that will provide you with additional information.

2. To use this system proceed as follows:

a. Arrange this subcourse booklet and your answer sheet (on reverse side of response list cover) so that they are convenient. Each exercise question has three choices lettered a, b, and c. Your answer sheet has three groups of numbers for questions 1 through 200. The numbers indicated for each question represent the a, b, or c choices.

b. Read the first exercise question and select the choice you think answers the question correctly. Go to the question 1 area of your answer sheet and circle the 3-digit number that corresponds with the choice you selected.

c. After you have identified the 3-digit number, locate it in the exercise response list. If you selected the right choice, the first word of the response will be "CORRECT." This tells you that you have answered the question correctly. Read the rest of the response which tells why your choice was correct and then go to the next question.

d. If the word "CORRECT" is NOT the first word of the response, you have selected the wrong answer. Read the response and then turn to the area in your study text that is mentioned. There you will find the information necessary for you to make another choice. Line out the incorrect 3-digit response on your answer sheet.

e. After you have reread the reference, select another answer and circle the 3-digit response for that choice. Again check the number of this second choice with the response list to see if your choice is now correct and to obtain more information about your choice. If your second choice is still not correct, line out the 3-digit response on the answer sheet and continue until the correct answer is selected. When you have answered all of the questions in an exercise, count the number of lined out responses and see how well you did.

f. You will notice that the lesson exercise question numbers continue consecutively from lesson to lesson. This allows you to use one answer sheet for the entire subcourse.

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IMPORTANT - Study these directions before going further.

DIRECTIONS FOR THE STUDENT

1. Congratulations. You are starting a new and different type of self-training subcourse called a correspondence/OJT subcourse. It is different from regular subcourses because it has tasks to be practiced on the job in addition to the usual lessons to be studied. This way, you can learn both the job skills and the job knowledge and become completely qualified in the subcourse matter.

2. Of course, you must be able to get to the equipment to practice these tasks. Some of you may not be able to do this. This is why you were asked to pick one of two options, or ways, that you wanted to take the subcourse.

a. If you are enrolled in the correspondence only option, you will study the lessons but you will not practice the tasks on the equipment. This means you will learn only the job knowledge of the subcourse. You will have to practice the job tasks sometime later when you can get to the equipment in order to learn the job skills. You will test yourself after each lesson by answering the lesson exercise questions using your answer sheet. Then you will be tested at the end of the whole subcourse by taking the enclosed multiple choice examination.

b. If you are enrolled in the correspondence/OJT option, you will do the whole subcourse. You will study all the lessons and practice all the tasks listed in each study text on the equipment. This way you will learn both the knowledge and the skills of the subcourse. Then you will be completely qualified in the part of your military occupational specialty (MOS) that is covered by this subcourse. You will test yourself after each lesson by answering the lesson exercise questions using your answer sheet. And, you will also take a subcourse multiple choice examination. However, in addition to these tests, you will take an application task test after finishing the subcourse examination. This application task test will be sent to your unit commander who will see that you are tested on the job tasks. It is important that you practice the tasks while you are studying the lessons so that you will be ready for the task test when you finish the subcourse.

c. You can understand that it is important to remember which of the two options you are enrolled in because the work you must do and the tests you must take will depend upon your option.

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3. This subcourse is one of several subcourses that make up the entire enlisted MOS correspondence/OJT course. If you are enrolled in the entire course, you will take this and all the other subcourses in order. If you are not enrolled in the entire course, then you will only take this and any other subcourses you asked for. Of course, you cannot become qualified in the complete MOS job unless you take the entire course. If you want to take the entire course later, you will be given credit for the subcourse(s) you have already passed.

4. Please check this subcourse packet to make sure that you have the following things:

a. A lesson booklet for each lesson listed in the introduction of lesson 1.

b. A lesson exercise response list and an answer sheet.

c. A multiple choice examination.

If any of these things are missing, please let us know right away.

5. If you are enrolled in the entire enlisted MOS correspondence/OJT course you must finish at least 60 credit hours or three subcourses each enrollment year. Your enrollment year begins the day you receive your first subcourse. If you are enrolled in certain subcourses only, you must finish each subcourse within 6 months after you receive it. However, you should finish each subcourse as quickly as you can so that you will qualify earlier for promotions.

6. You must study the subcourse material starting with lesson 1 and progress through the rest. Beginning with lesson 1, scan the lesson assignment sheet. It lists the lesson title, credit hours assigned to the lesson, lesson objective, study assignment, and suggestions.

a. Go through the lesson exactly as you are told by the study assignment and the suggestions in the lesson assignment. Also follow any directions given throughout the study text.

b. Read the lesson through once; reread and study any portion that you did not understand. After you are sure you understand the study material, answer the exercise questions at the end of the lesson. Then practice the job tasks on the equipment.

US ARMY ORDNANCE CENTER AND SCHOOL

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B207, WHEELED VEHICLE STEERING SYSTEMS

(13 Credit Hours)

INTRODUCTION

Any vehicle would be of little use if it could not be directed or guided on a desired course. The act of guiding the vehicle is called steering. Wheeled vehicles are steered by aiming or pointing the wheels in the direction that we want the vehicle to go. As you know, the driver of a car or truck guides it by turning the steering wheel. The steering system of cars and trucks consists of the levers, links, rods, gear box, and, in many cases, a hydraulic system that assists the driver's steering effort.

The steering system is of critical importance in the safe operation of the vehicle. There must be no looseness between the steering wheel and the front wheels if the driver is to keep control over the direction in which the wheels point. The tires must meet the road at the correct angle to get good traction and to prevent unnecessary tire wear. In addition, the driver should be able to hold the wheels in the straight-ahead position and change them to the right or left with very little effort.

For you, the student, a study of steering systems introduces many new words, parts, ideas, and theories. The study includes some math, physics, and hydraulics. It is the aim of this subcourse to provide you with a thorough understanding of the design, construction, operation, and organizational maintenance of steering systems. Math, physics, and hydraulics are covered right in the text where they apply. When you see a new word, a new part, a new idea, or a new theory you should be sure you know what it means, how it works, and why it works before you continue.

This subcourse consists of five lessons, an examination, and an application task test. They are organized as follows:

Lesson 1 Fundamentals of Hydraulics
Scope—A study of basic principles of fluids under pressure, the means by which hydraulics can be used to multiply force, and the construction and operation of hydraulic system components.

Lesson 2 Introduction to Wheeled Vehicle Steering Systems
Scope—An explanation of the contruction and operation of mechanical and power steering gears and steering linkages; also, the principles of steering geometry.

Lesson 3 Maintenance of Mechanical Steering Gear Assemblies
Scope—A description of the procedures used for the inspection, testing, adjustment, and repair of mechanical steering gears; the removal and installation of assemblies; and the replacement of repair parts.

Lesson 4 Maintenance of Power Steering Gears
Scope—The inspection, testing, adjustment, and repair of power steering gears and their associated hydraulic equipment; removal and installation of assemblies; and the replacement of repair parts.

Lesson 5 Maintenance of Steering Linkages
Scope—The inspection, testing, adjustment, and repair of steering linkage components; the replacement of repair parts; front-wheel alinement procedures; and troubleshooting steering systems.

Examination
Scope—The examination is designed to test the student's knowledge of the subject material covered in the subcourse.

Application Task Test
Scope—The application task test is designed to test the OJT student's ability to perform tasks associated with the subject material presented in the subcourse.

//

CHECKLIST OF TEXTS AND MATERIALS FURNISHED

Ordnance Subcourse No 63B207
October 1975

No texts, other than the Attached Memorandums, are used in support of this subcourse. Therefore, you are not required to return any texts to the US Army Ordnance Center and School.

This subcourse may contain errata sheets. Make certain that you post all necessary changes before beginning.

Note. - Any publications cited in this subcourse are general references and are not furnished. The following publications were used in preparation of this subcourse:

TM 5-350	Hydraulic Power Control Systems, Nov 63
TM 9-2320-206-20, w/C2, 4	Organizational Maintenance Manual: 10-Ton, 6x6, M123-Series Truck Tractor, Oct 71
TM 9-2320-209-20, w/C1-6	Organizational Maintenance Manual: 2-1/2-Ton, 6x6, M34-, M35-, and M36-Series Trucks, Apr 65
TM 9-2320-212-20	Organizational Maintenance Manual: 3/4-Ton, 4x4, M37-, M43-, and M201-Series Trucks, Nov 73
TM 9-2320-218-20, w/C2	Organizational Maintenance Manual: 1/4-Ton, 4x4, M151-Series Trucks, Sep 71
TM 9-2320-244-20, w/C1, 2	Organizational Maintenance Manual: 1-1/4-Ton, 4x4, M715 and M725 Trucks, Aug 71
TM 9-2320-260-20	Organizational Maintenance Manual: 5-Ton, 6x6, Tractor Trucks, Cargo Trucks, and Wreckers, Jul 72
TM 9-8000	Principles of Automotive Vehicles, Jan 56
TM 9-8024, w/C3, 5-7	Organizational Maintenance Manual: GMC-Series 2-1/2-Ton, 6x6, Trucks, Oct 55

US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B207 . . . Wheeled Vehicle Steering Systems

Lesson 1 . . . . Fundamentals of Hydraulics

Credit Hours . . . . Two

Lesson Objective . . . . After studying this lesson you will be able to:

1. Describe the nature of liquids.
2. Describe the fundamental principles of gaining mechanical advantage using hydraulics.
3. Describe the purpose, construction, and operation of valves commonly used in automotive hydraulic systems.
4. Describe the purpose, construction, and operation of pumps commonly used in automotive hydraulic systems.
5. Describe the purpose, construction, and operation of cylinders commonly used in automotive hydraulic systems.

6. Describe the purpose, construction, and operation of accumulators commonly used in automotive hydraulic systems.
7. Describe the purpose and construction of reservoirs commonly used in automotive hydraulic systems.
8. Describe hydraulic fluids and their use as applied to automotive equipment.
9. Explain the operation of a simple hydraulic jack.

Text	Attached Memorandum
Materials Required	Answer sheet and response list
Suggestions	As you read the lesson pay careful attention to all of the accompanying illustrations. They will help you to understand the principles that are discussed.

FOREWORD

You have probably heard the term "hydraulics" used many times. Such things as hydraulically operated jacks, cranes, and barber chairs are well known to almost everyone. Hydraulic parts are very common to wheeled vehicles, too. For example, they use hydraulic power steering, hydraulic brakes and hydraulic lifts for cargo beds and booms. The basic principles of hydraulics are the same regardless of whether we are applying them to a barber chair or to a complex automotive hydraulic system. Whenever a hydraulic system does not work, the repairman or mechanic will need a thorough understanding of hydraulic principles in order to troubleshoot the system and to make the necessary repairs.

ATTACHED MEMORANDUM

SECTION I. HYDRAULIC PRINCIPLES

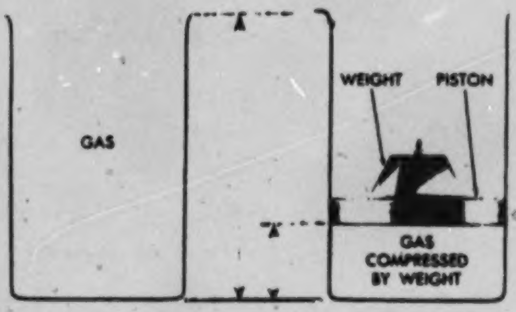
1. INTRODUCTION. The word "hydraulics" is based on the Greek word for water, and at first it applied only to the study of how water behaved when it was at rest and in motion. Present-day use has broadened its meaning to cover the behavior of all liquids.

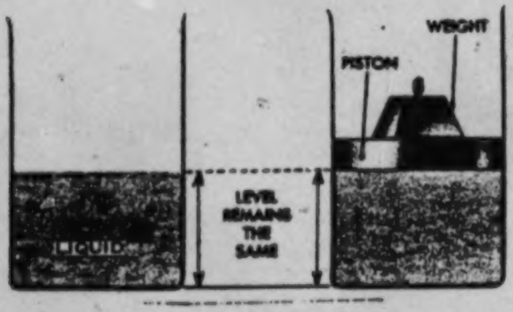
a. A present-day study of hydraulics includes, for example, the manner in which all liquids act in tanks and pipes. It includes floating bodies, pressures exerted on surrounding objects, flow of liquids under various conditions, and the ways used to direct this flow to useful ends.

b. This lesson will deal primarily with the study of hydraulics as it applies to automotive vehicles, especially to wheeled vehicles used by the US Army.

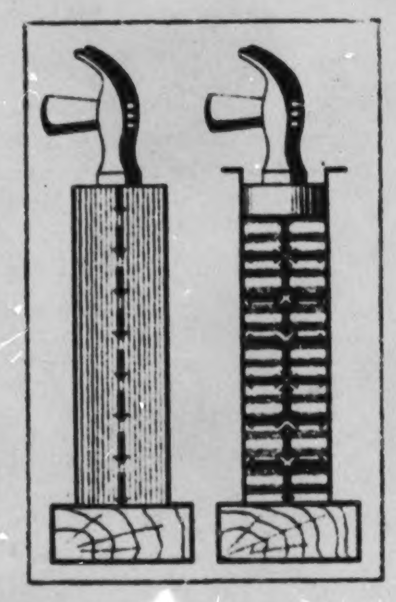
2. NATURE OF LIQUIDS. While solids always have a definite shape, liquids have no outer form of their own. Liquids always take the shape of their container. Because of their own shapelessness, liquids can be sent almost anywhere in a pipe or a hose by means of gravity or by any other means of applying a force to them. Liquids are second only to electricity in ease of transmission.

a. Everyone knows that a gas, which also has no shape of its own, can be easily compressed. This can be demonstrated if we have a container filled with a gas, such as air, and sealed with an airtight piston. If we place a weight on top of the piston it will move down, compressing or squeezing the air inside the container into a smaller space.

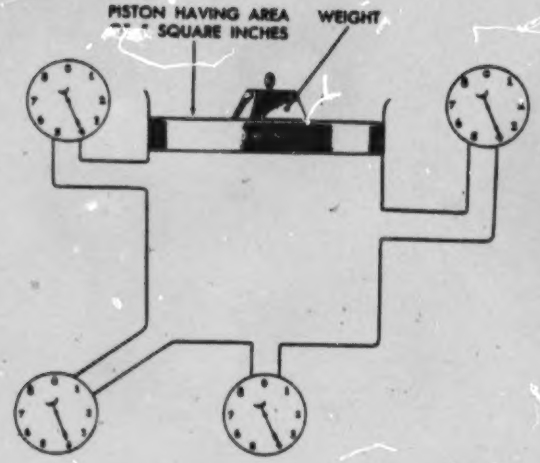




b. Even though they also have no shape of their own, liquids act much differently from gases because they will compress very little. This can be demonstrated if we put a liquid instead of gas in the container. Now, if a weight is placed on the piston there will be no noticeable movement of the piston, because the liquid has not been compressed any noticeable amount. In fact, a force of 15 pounds on a cubic inch of water will only compress it about 1/20,000. For practical use in automotive hydraulic systems, we can think of liquids as not being compressible at all.



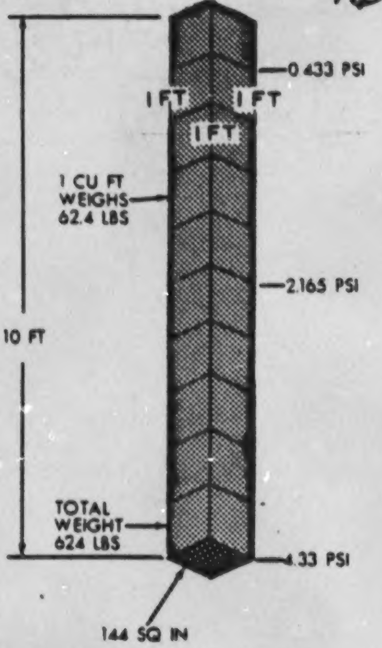
3. **DISTRIBUTION OF PRESSURE.** When we strike the end of a block of wood, the main force of the blow is carried straight through the block to the other end. This happens because the block is rigid. The direction the blow is struck determines the direction of most of the force. On the other hand, if we strike the piston in a cylinder of liquid, the force is carried not only straight through to the other end, but also equally in every direction throughout the cylinder.



a. We can show that pressure is distributed equally in a confined liquid by using a cylinder that has several branches or pipes. The cylinder and pipes must be filled with liquid and a pressure gage attached at each pipe. A piston is placed on top of the liquid. For the present, let's say the piston has 5 square inches of surface that touches the liquid. Now, if we place a weight on the piston so that the weight of the piston plus the weight totals 20 pounds, each gage will indicate a pressure of 4 pounds per square inch. This is usually written 4 PSI.

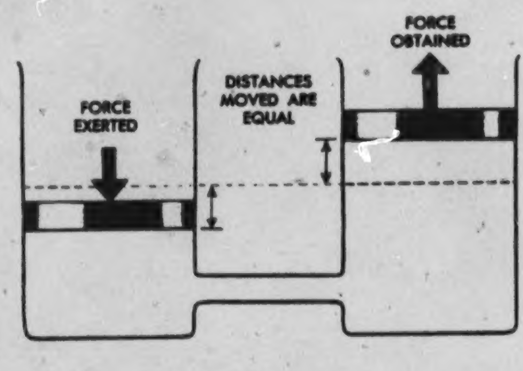
b. Since the 20 pounds of weight is spread out evenly over the 5 square inches of piston area, the pressure exerted on each square inch is 4 pounds (20 ÷ 5 = 4). The amount of pressure throughout the liquid and the amount indicated by the gages is, therefore, 4 PSI.

c. In this experiment we were assuming that we had a short cylinder, so the weight of the liquid itself did not affect the pressure reading on the gages. If we had used a tall cylinder, we would have noticed that the pressure was higher near the bottom of the container, since the weight of the liquid above would have added to the pressure being applied by the 20-pound weight. There is very little difference in the height of the different hydraulic components in automotive equipment, so the weight of the liquid is not considered when referring to pressures in an automotive hydraulic system.

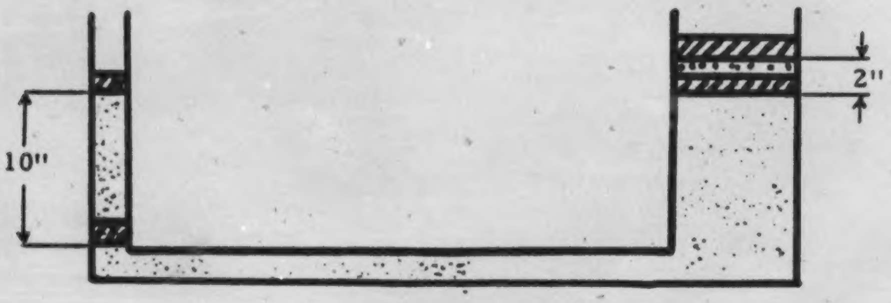

0.433 PSI
1 FT
1 FT
1 FT
1 CU FT WEIGHS 62.4 LBS
2.165 PSI
10 FT
TOTAL WEIGHT 624 LBS
4.33 PSI
144 SQ IN

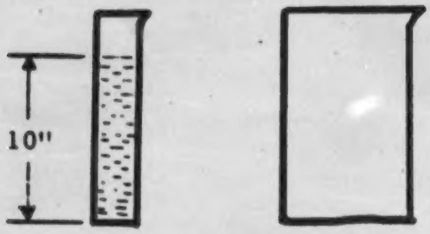
Water column.

4. VOLUME AND DISTANCE FACTORS. Now let's assume that we have two identical cylinders connected by a pipe. They are fitted with pistons and filled with liquid. An interesting fact about this arrangement is that we can transfer force from one cylinder to the other through the liquid. That is, if we push the piston down in one cylinder, the piston in the second cylinder will move up. This is caused by the liquid being pushed out of one cylinder through the connecting pipe and into the second cylinder. It should also be noticed that the two cylinders are the same diameter and that both pistons move the same distance.

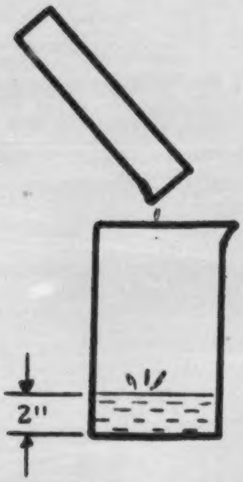

FORCE OBTAINED
DISTANCES MOVED ARE EQUAL
FORCE EXERTED

a. Now let's consider two interconnected cylinders that are not the same size. Assume that one cylinder piston has a surface area of 1 square inch while the second one has 5 square inches of surface area. With this arrangement, pushing the small piston down 10 inches will raise the large piston 2 inches. The reverse of this is also true; that is, pushing the large piston down 2 inches will raise the small piston 10 inches.

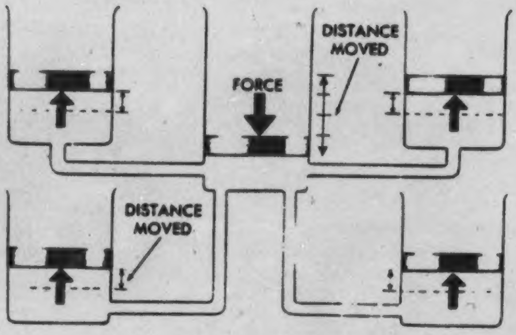




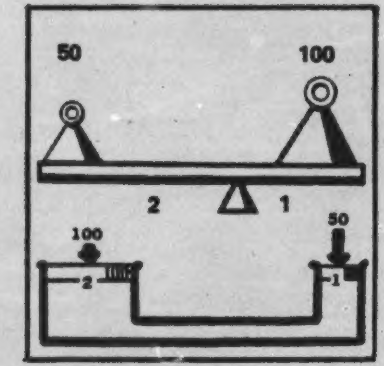
b. The reason for the difference in the amount of piston movement can be easily shown with two containers that are the same size as the two cylinders. By filling the slender container with liquid to a depth of 10 inches, it will contain the same amount of liquid that was displaced by pushing the piston down 10 inches in the slender cylinder. Now if we pour the liquid from the slender container into the wide container, the water level will rise to a depth of only 2 inches. The liquid takes the shape of the wider container by spreading out more but not rising as high.



c. In some applications of hydraulics, force is applied to a piston in one central cylinder and the liquid pushed out moves the pistons in several other cylinders. For example, let's assume that we have an arrangement of 5 cylinders. If all cylinders are the same size, the force exerted on the central cylinder piston will be transmitted equally to the other four pistons, but they will move only one-fourth as far as the central piston. If the four cylinders have a larger diameter than the central one, the total force on each of the four pistons is greater than that applied to the central one; however, each of the four pistons moves less than one-fourth as far as the central piston. Hydraulic brake systems operate in such a manner.



5. MECHANICAL ADVANTAGE RATIOS. We can apply what we know about the mechanical advantage of levers to hydraulic situations. With a lever, a 50-pound weight can balance a 100-pound weight. The 50-pound weight must be set twice as far from the balancing point as the 100-pound weight. This is known as a mechanical advantage ratio of 2 to 1, which is usually written as 2:1. In hydraulics, 50 pounds on a piston of a certain area can balance a 100-pound weight on a cylinder piston having twice that area. In this way a mechanical advantage ratio of 2:1 is gained hydraulically.



a. To see just how the mechanical advantage is gained through the liquid, imagine that the area of the small piston is 1 square inch and the larger piston 2 square inches. The 50-pound weight on the small piston then exerts a pressure of 50 pounds per square inch on the liquid, which is distributed equally in the liquid throughout both cylinders and the connecting pipe. The total pressure pushing upward on the 2 square inches of surface of the large piston is 100 pounds, disregarding any loss due to friction between the pistons and cylinders. The advantage ratio is 2:1 because the large piston has twice the area of the small piston.

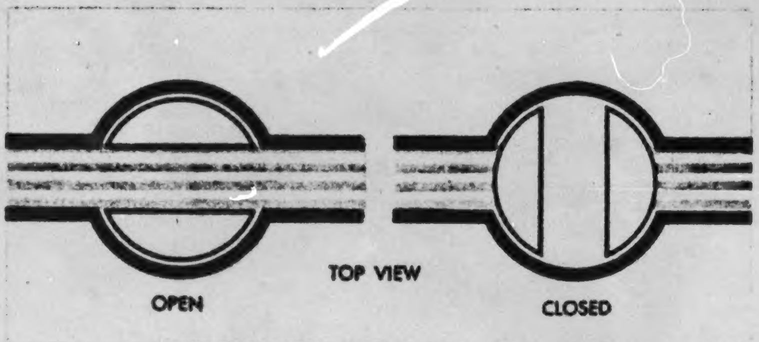
b. In a hydraulic system, just as with the lever, we have to give up distance to gain force. If the ratio is 2:1, the smaller piston will move twice as far as the large piston, so the ratio of 2:1 applies to the difference in piston travel as well as to the difference in force. If the ratio is 3:1, the smaller piston must move three times farther than the larger piston, but the large piston will balance three times the weight that is exerted on the small piston.

SECTION II. HYDRAULIC DEVICES AND FLUIDS

6. GENERAL. So far we have discussed how pressure on a liquid causes it to act in hydraulic systems. We have not considered all of the necessary parts that are needed to make up a basic hydraulic system. Under actual working conditions, valves are required to direct and control the flow of liquid, a pump is needed to supply a flow of liquid under pressure, a cylinder or motor is needed to convert the liquid flow to mechanical motion, a reservoir is needed to store a liquid supply, and lines are needed to carry the liquid between the units. In addition, a liquid is needed that will not cause damage to the hydraulic parts and yet is suitable for use over a wide temperature range.

7. VALVES. Simply stated, all valves are an opening in a pipe with some means of closing it. Let's take a look at some common types of valves that are widely used.

a. One type of valve is called a cock. This valve has a plug seated in the path of the liquid flow. The plug has an opening running through it to permit flow when the valve is open. Flow is stopped by turning the plug 1/4 of a turn so that the opening is crossways to the flow. A part of the plug sticks out so that the operator or mechanic can turn it manually. Cocks are designed to be left only in the fully open or fully closed positions.



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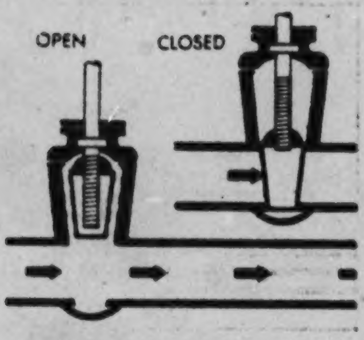
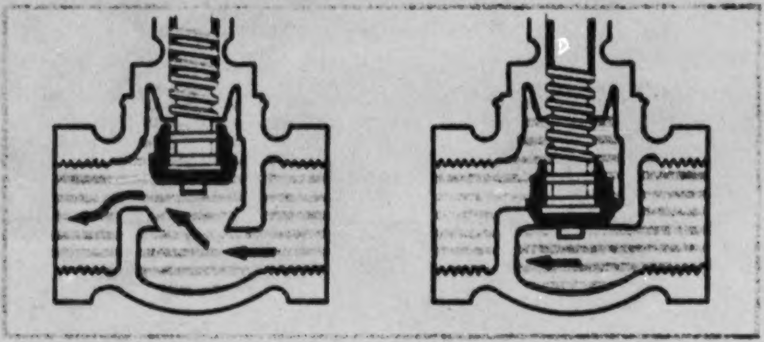
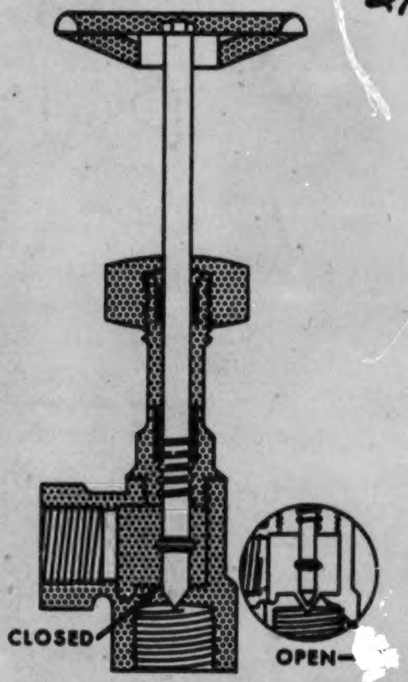


b. A gate valve is a wedge-shaped gate that can be moved out of, or across, the line of liquid flow to allow or to stop the liquid flow. Usually, the valve has a threaded stem for controlling it that must be rotated several turns to move the gate from the fully open position to the fully closed position. Sometimes gate valves are left partly open to regulate the amount of flow, but they are intended for fully open or fully closed use. If left in the partly open position, the flowing liquid will cause an unequal wear on the valve's sealing surface.

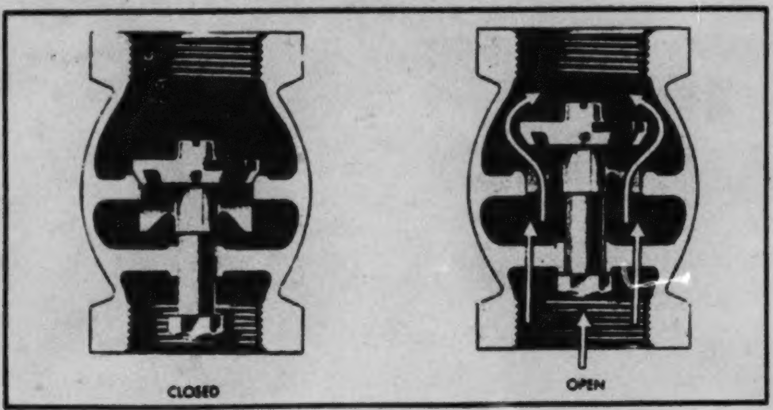
c. The globe valve is made with a disc-shaped controlling member that is lowered against a seat to stop flow and raised to permit flow. Several turns of a valve stem are usually required to move the valve from one extreme to the other. Because of the design of this type of valve, it can be kept in a partly open position to control the amount of flow without causing unequal wear on the sealing surfaces. The valve should always be installed with pressure against the face of the disc-shaped controlling member.



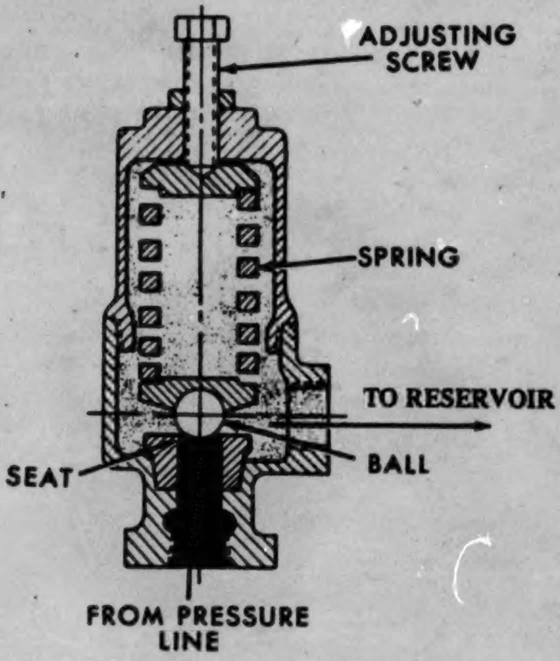
d. Needle valves are made a lot like globe valves. Instead of a disc, a needle valve with a tapered point is at the end of the valve stem. The tapered point permits the needle valve to be opened or closed gradually. Needle valves allow the amount of liquid flow to be manually adjusted very accurately.



e. A check valve is made so that it is automatically opened and closed by a difference in liquid pressures between its inlet and outlet openings. It is used in a system to allow flow in one direction only. The force of the liquid in motion in one direction will open the valve, while an attempt by the liquid to flow in the opposite direction will force the valve closed. Closing is also assisted by a spring or gravity. When the assistance is by gravity, the valve must be positioned so that the weight of the controlling member closes the valve when there is no liquid flow.

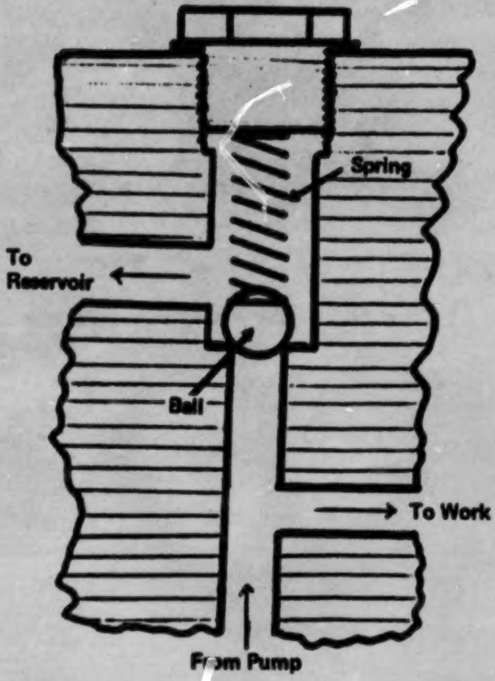


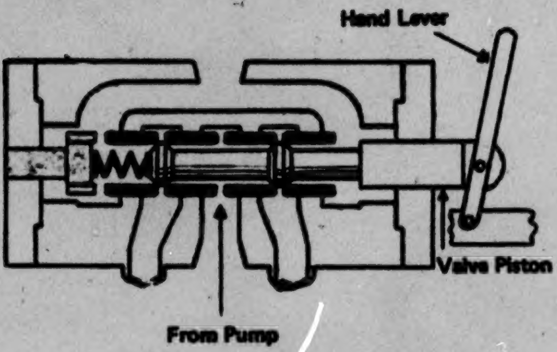
f. Often a pressure regulator valve is installed in a hydraulic pressure line to make sure that liquid pressure does not go above a certain amount to protect the system from high pressure. Regulator valves are also usually called relief valves. They are like check valves because they permit liquid to flow through them in one direction only.


ADJUSTING SCREW
SPRING
TO RESERVOIR
SEAT
BALL
FROM PRESSURE LINE

(1) A regulator valve contains a spring to hold the controlling member in the closed position. When liquid pressure pushing on the face of the valve is great enough, it compresses the spring and opens the valve. The amount of pressure required to open the valve can be changed by changing the spring pressure holding the valve closed.

(2) Liquid flowing to do the work does not flow through the regulator valve. The valve is connected so that it will have no effect on the rest of the system. When the pressure exceeds the regulator spring pressure, the valve opens and excess liquid pressure is bypassed to the reservoir or pump intake.

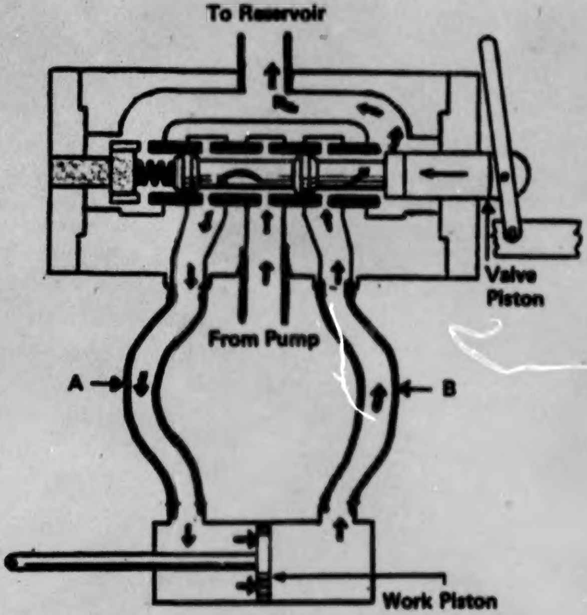

Spring
To Reservoir
Ball
To Work
From Pump



g. Some hydraulic systems use spool valves for controlling the direction of liquid flow. A spool valve has a spool-shaped piston that is moved to open and close passages in a cylinder to direct the flow. The piston usually has a spring that holds the valve in the neutral position. When in neutral, the valve does not allow liquid to flow between the valve and the work.

(1) Spool valves are commonly used to control liquid flowing to and from a cylinder. If the cylinder piston is to do work in both directions of its travel, there will be two lines connected between the cylinder and valve - one to each side of the cylinder piston. In addition, the spool valve has two more lines connected to it - one to carry liquid under pressure from the pump, and another to return liquid to the reservoir or liquid supply tank.

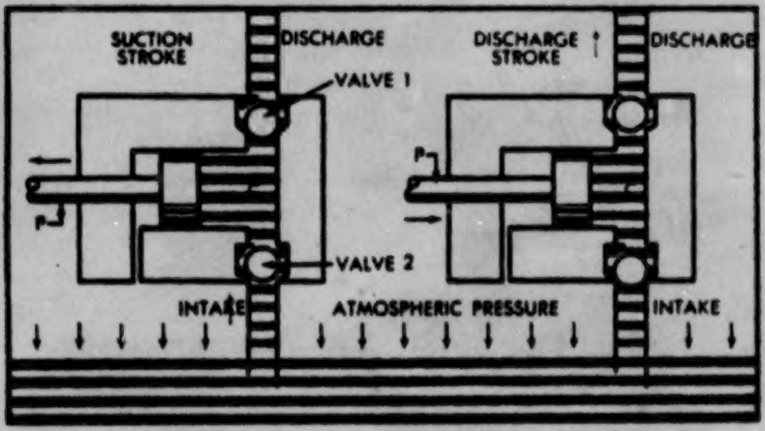
(2) Suppose that the valve piston is moved to the left as shown in the illustration. Liquid under pressure can now flow from the pump through the valve and line A to the cylinder. This will force the cylinder work piston to the right. The work piston pushes oil from the right side of the cylinder through line B and the spool valve to the reservoir.



(3) The work piston can be stopped at any desired position by releasing the lever controlling the valve piston and allowing the spring to return the valve to the neutral position. This blocks liquid flowing both to and from the cylinder and the liquid trapped on each side of the work piston holds the piston firmly in position.

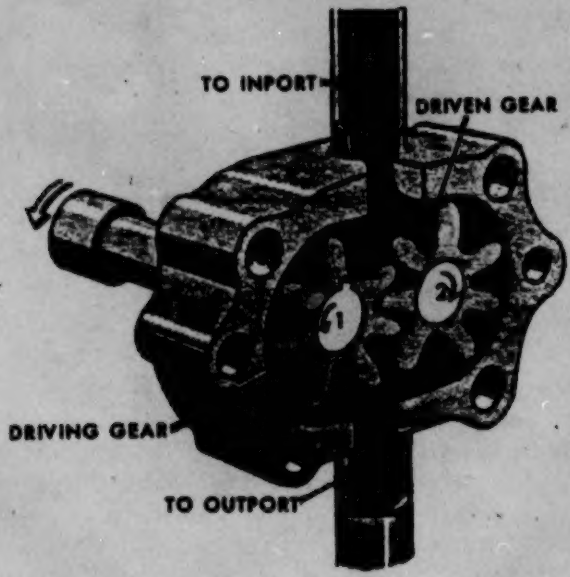
(4) If the valve piston is moved to the right, liquid will flow from the pump through the spool valve and line B to the right side of the piston. The piston then moves to the left, pushing oil through line A and the spool valve to the reservoir.

8. PUMPS. A hydraulic pump is a device through which an external source of power is used to apply force to a liquid. In automotive vehicles the vehicle engine usually supplies the power to drive the pump. But in a few cases an electric motor drives the pump. Two general classifications of pumps are positive displacement and nonpositive displacement. A positive displacement pump is one in which a definite volume of liquid is pumped for each cycle of pump operation, regardless of the resistance offered to flow. A nonpositive displacement pump is one in which the amount of liquid pumped depends on the amount of resistance offered to flow. Pumps used in automotive hydraulic systems are the positive type, of which there are several designs. We will discuss the reciprocating, gear, and vane designs in this lesson.



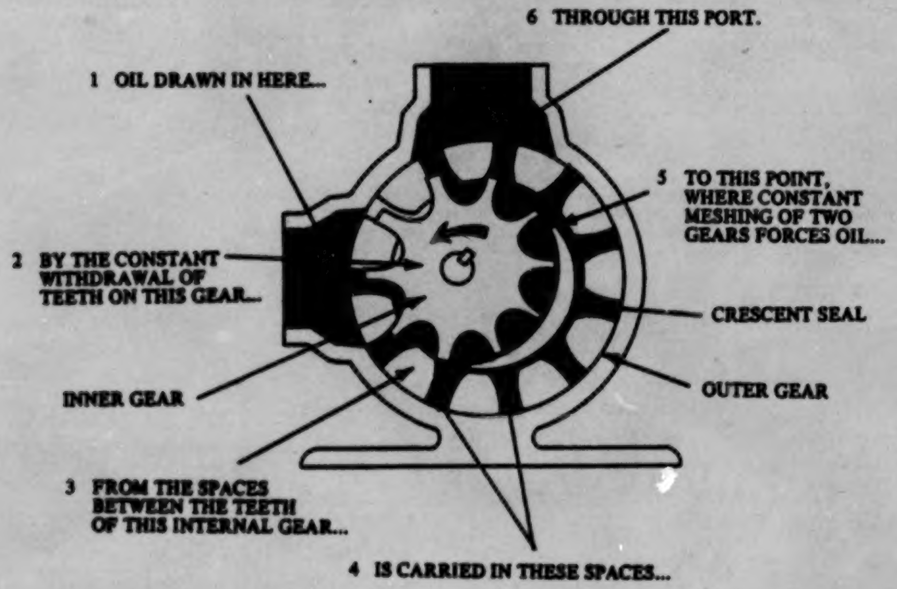
a. The reciprocating pump has a piston that fits closely inside a cylinder. The cylinder contains intake and discharge check valves. The pump is operated by a back-and-forth movement of the piston. When the piston is pulled to the left (as shown in the illustration), liquid is drawn into the cylinder through the intake check valve. When the piston is moved to the right, it puts pressure on the liquid, closing the intake check valve and forcing liquid out through the discharge check valve. The piston can be operated from the rotary motion of the engine by means of a crankshaft or cam, or it may be manually operated by a lever.

b. The gear pump is one of the simplest pumps in construction. It has two gears in a casing. There is very little space between the gear teeth and the pump casing and between the gear teeth where they mesh. Gear pumps are easily coupled to an engine because they operate with a rotary motion.

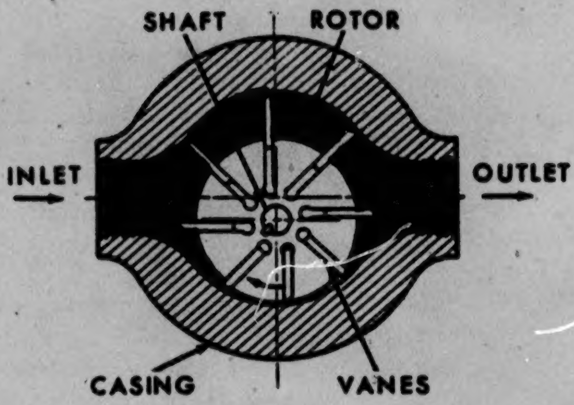

TO INPORT
DRIVEN GEAR
1
2
DRIVING GEAR
TO OUTPORT

(1) One gear pump design has two gears with external teeth. One gear is a drive gear; the other a driven gear. As the gears rotate, liquid is trapped between the gear teeth and the casing at the pump intake (A). The trapped liquid is carried to the pump discharge (B). As liquid is continually carried from the pump intake to the discharge, it is forced out the discharge opening because it cannot flow back past the meshed gear teeth.

(2) Some gear pumps have an internal gear with an external gear mounted inside it. The internal gear is mounted off-center so its teeth mesh with the internal gear teeth on one side only. The gear's teeth are separated on the opposite side by a crescent-shaped portion of the casing. In operation, liquid is trapped between the gear teeth at the intake of the pump and carried past the crescent to the discharge.

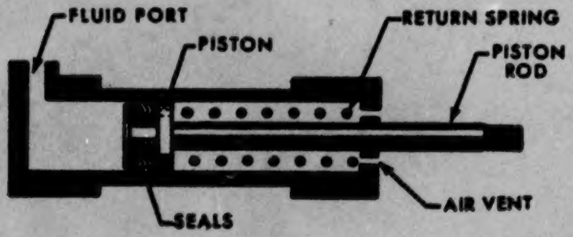

6 THROUGH THIS PORT.
1 OIL DRAWN IN HERE...
5 TO THIS POINT, WHERE CONSTANT MESHING OF TWO GEARS FORCES OIL...
2 BY THE CONSTANT WITHDRAWAL OF TEETH ON THIS GEAR...
CRESCENT SEAL
INNER GEAR
OUTER GEAR
3 FROM THE SPACES BETWEEN THE TEETH OF THIS INTERNAL GEAR...
4 IS CARRIED IN THESE SPACES...

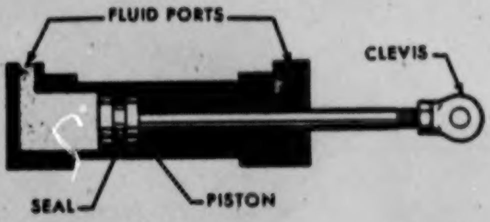
c. Vane pumps have a rotating part called the rotor which has slots fitted with movable vanes. The rotor is placed off-center inside an oval-shaped cavity in the pump casing. The intake and discharge ports are located on opposite sides of the cavity. As the rotor spins, the vanes are thrown out against the wall of the oval cavity. The vanes slide in and out in the rotor slots following the shape of the cavity. At the pump intake, liquid is trapped and swept around in pockets formed by the rotor, vanes, and walls of the housing cavity. Because of the off-center mounting of the rotor, the size of each liquid pocket gets smaller and the liquid is squeezed out through the pump discharge port when the pocket alines with the port.



9. CYLINDERS. A hydraulic cylinder is a device that changes liquid flow to mechanical straight line motion. A hydraulic cylinder consists of a barrel, or housing, in which a piston slides. A piston rod is connected to the piston to attach the piston to the load. The end of the cylinder where the rod sticks out is called the rod end, and the opposite end is called the head end. Hydraulic cylinders are classified as being either single-acting or double-acting.

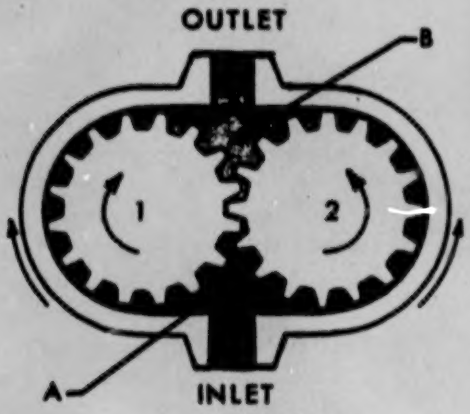
a. A single-acting cylinder has a port in one end only - usually the head end - and is operated hydraulically in one direction only. When a valve is opened, allowing liquid to be pumped into the port, the liquid pushes on and moves the piston which extends the piston rod. Before the piston and rod can be retracted, the controlling valve must be positioned so liquid in the cylinder can be released to the reservoir. The cylinder is then returned to the retracted position by the weight of the work or by a return spring.





b. In the double-acting cylinder the liquid can move the piston in both directions. The cylinder must have ports at both the head end and the rod end. Pumping liquid into the head end moves the piston to extend the rod. At the same time, any liquid trapped in the rod end of the cylinder is pushed out and returned to the reservoir. To retract the rod, flow is reversed. Liquid from the pump goes into the rod end and liquid pushed out the head end port goes to the reservoir.

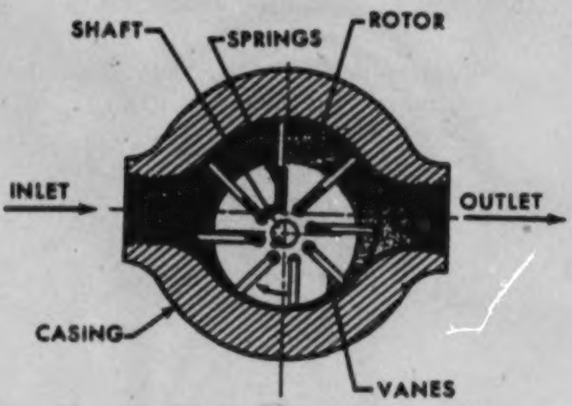
10. MOTORS. Hydraulic motors perform a function opposite to that of hydraulic pumps. In fact, we could say that a motor is a pump that is being pushed by the liquid flow instead of doing the pushing. There are about as many different designs of motors as there are pumps. In this lesson we will only discuss the gear type and vane type, as they are the most commonly used motors in automotive hydraulic systems.



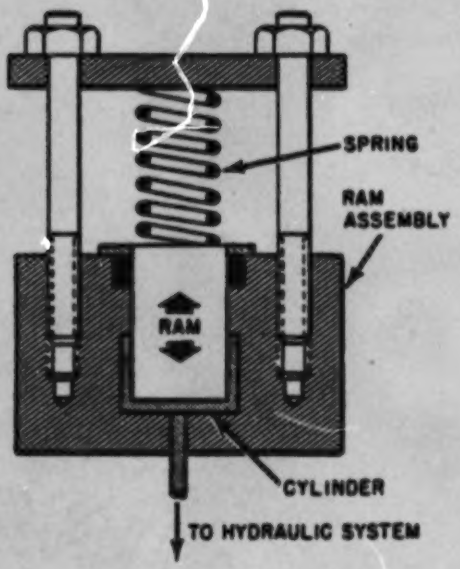
a. Basically, the gear-type motor is made just like the gear-type pump. In a motor, both gears are driven gears, but only one is connected to the output shaft. Liquid flow from a pump enters chamber A (as shown in the illustration) and flows around the inside surface of the casing, forcing the gears to turn. When the liquid enters chamber B it is directed to the reservoir. The direction of motor rotation can be reversed simply by reversing the liquid flow.

28

b. Construction of the vane-type motor and the vane-type pump usually differs in the mounting of the vanes in the rotor. Recall that in the pump the vanes are thrown outward as the rotor spins. In the motor some means must be provided to hold the vanes out before a liquid flow can cause the rotor to turn. Springs are often used for this purpose. In operation, liquid flow from the pump enters the motor inlet, forcing the rotor to rotate as it passes through the motor. From the motor outlet, liquid flows to the reservoir.

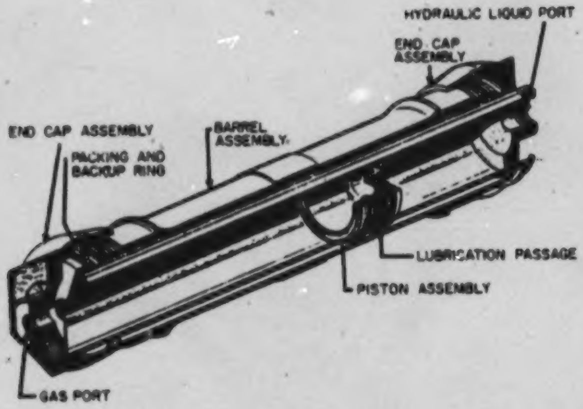


11. ACCUMULATORS. Some hydraulic systems use a part called the accumulator. An accumulator is to a hydraulic system what the battery is to an electrical system. It stores energy, in this case liquid under pressure, for future use. It can supply liquid flow for a short time in case of pump or power failure, and it can supplement the pump supply when the system momentarily demands large quantities of liquid. In addition, accumulators provide a shock absorbing (cushioning) action for the hydraulic system.



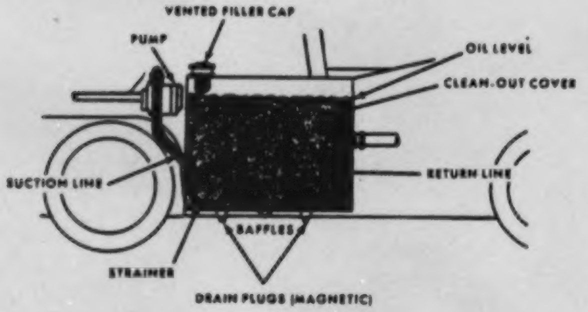
a. Spring-loaded accumulators are used in the hydraulic systems on some automotive equipment. These units consist of a cylinder fitted with a ram or piston that is spring loaded. Liquid from the system is pumped into the cylinder under the ram. The pressurized liquid pushes the ram up, compressing the spring above the ram until the spring pressure and liquid pressure are equal on each side of the ram. If liquid pressure in the system lowers for any reason, the compressed spring moves the ram down, pushing liquid from the accumulator to maintain the flow in the system. The size of the accumulator used and the strength of the spring needed will depend on the volume and pressure requirements placed on it by the system.

b. Another accumulator design, the piston type, is also used on automotive equipment. It contains a free-floating piston in a cylinder. The cylinder is sealed at each end by a cap. The accumulator is charged with a gas, such as air or nitrogen, by forcing it into the cylinder on one side of the piston. A port at the opposite end of the cylinder is connected to the pressure line in the hydraulic system. Since the gas is compressible, it acts just as the spring in the spring-loaded accumulator. The amount of liquid pressure that can be stored by the piston-type accumulator will be governed by the pressure of the gas charge.


HYDRAULIC LIQUID PORT
END CAP ASSEMBLY
END CAP ASSEMBLY
BARREL ASSEMBLY
PACKING AND BACKUP RING
LUBRICATION PASSAGE
PISTON ASSEMBLY
GAS PORT

12. RESERVOIRS. In addition to being a supply tank to hold hydraulic fluid, the reservoir also aids in cooling the fluid, separates air from the fluid, and helps separate the fluid from dirt and other harmful matter that has gotten into the system. The reservoir may contain many parts and be large enough to hold 40 to 50 gallons of fluid or it may be very simple and hold as little as 1/2 pint. The exact capacity of the reservoir will depend on the requirements of each particular system.

a. Generally, hydraulic reservoirs are high and narrow rather than shallow and broad. This is so the oil level will stay high above the intake or suction line to the pump when the vehicle is being operated on uneven ground. The reservoir must be large enough so that it will still contain a reserve of fluid with all the cylinders in the system fully extended. Also, it must be able to hold the fluid when all the cylinders are retracted, with some spare space to allow for expansion when the fluid is hot.


VENTED FILLER CAP
PUMP
OIL LEVEL
CLEAN-OUT COVER
SUCTION LINE
RETURN LINE
BAFFLES
STRAINER
DRAIN PLUGS (MAGNETIC)

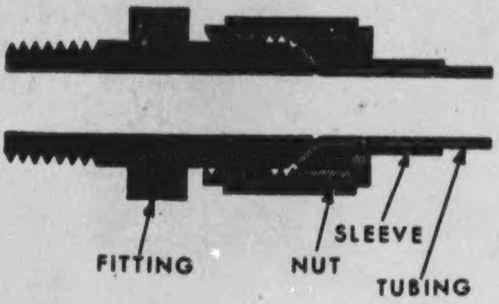
b. Many reservoirs contain baffle plates that are placed between the suction line and the return line. Circulation holes in the baffles are positioned at the edges of the baffles. This is so the liquid must pass next to the outer walls of the reservoir when flowing from one side of a baffle to the other to provide better cooling. The baffles also reduce sloshing when the vehicle is moving.

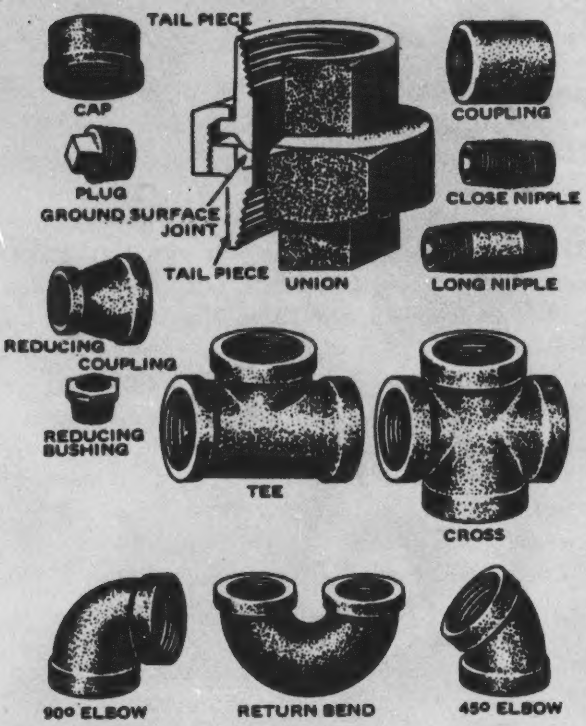
c. Often a strainer or filter is placed over the suction line to make sure that only clean fluid is pumped into the system. A screen may be placed in the filler opening to screen foreign particles out of fluid when refilling the reservoir. Sometimes the drain plug in the reservoir may be magnetized to attract metal particles that may be in the fluid.

d. Most reservoirs are vented to allow air to leave or enter the space above the fluid as the level of the fluid goes up and down. The air may vent through the filler cap which often contains a filter to prevent dirt from entering with the air. If the vehicle is equipped to ford bodies of water, the vent usually consists of a line connected between the reservoir and the air intake system of the engine.

13. LINES. Lines that are used to connect the components in automotive hydraulic systems must be strong enough to withstand the pressures that are developed in the systems. They must also be large enough to prevent restricting the normal flow of liquid. Fittings must be provided at places where parts require removal for repair or replacement. The three common types of lines that are used are tubing, pipes, and flexible hoses.

a. Tubing is widely used where rigid connections can be used. Flared tube-type fittings are used at points that must be disconnected for repair. Unlike pipe, tubing can be cut, flared, and fitted in the field.




TAIL PIECE
CAP
COUPLING
PLUG
CLOSE NIPPLE
GROUND SURFACE JOINT
TAIL PIECE
UNION
LONG NIPPLE
REDUCING COUPLING
REDUCING BUSHING
TEE
CROSS
90° ELBOW
RETURN BEND
45° ELBOW

b. Pipes are also a rigid connection, but in automotive hydraulic systems they are not as common as tubing. Pipes are threaded on their ends to provide disconnect points. Pipes and pipe fittings are taper threaded and cannot be interchanged with other types of fittings that have straight threads.

c. When there is a need for flexible connections, hoses are used. Both flared tube and pipe fittings are fastened at their ends to flexible hoses for connecting them into the system. A flexible hose normally consists of rubber-like tubes and layers of cotton and/or wire braid. An inner tube is used to seal the fluid. The purpose of the braid, which may consist of several layers covering the inner tube, is to add strength to the hose. A rubber-like tube covers the outer layer of braid to protect it from snags.

14. FLUIDS. Most of the liquids used in hydraulic systems and devices on automotive vehicles are made from mineral, vegetable, or animal oils. Water is never used because it will boil and freeze too easily. In addition, it will cause metal parts to rust. Alcohol, or similar liquids, is often added to the oil to produce a hydraulic fluid that is not too thick, and has good cleaning and lubricating qualities.

a. The Army's technical manuals that apply to vehicles and other items of equipment that have hydraulic systems or devices always specify the types of hydraulic fluid to use. NEVER put a fluid in any hydraulic system or device unless you are absolutely sure it is the right fluid for that particular system or device.

(1) In some cases, plain engine oil is used. For example, the fluid used in the hydraulically operated boom on the 5-ton wrecker is engine oil. Engine oil is also used in the hydraulic power steering system of the 5-ton wrecker and some other heavy trucks.

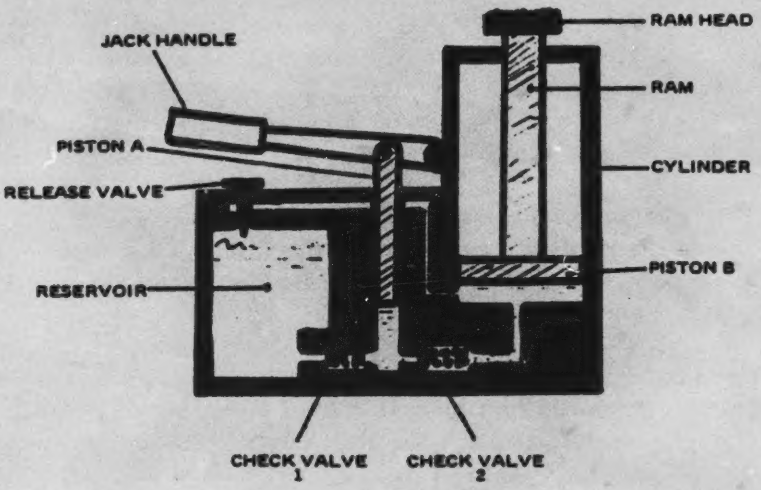
(2) On the other hand, engine oil, which is a mineral oil, cannot be used in the hydraulic brake systems of wheeled vehicles. The brakes contain rubber piston seals that are quickly destroyed by mineral oils. A special mixture containing vegetable oil is used in hydraulic brake systems.

b. The fluid level in any hydraulic reservoir should be kept at the level recommended in the proper technical manual. If the level is too high, the fluid may overflow or blow seals because of expansion of the fluid at high temperatures. If the level is too low, condensation (water) can form in the reservoir. Water will cause the parts to rust and fail. A low fluid level can also allow the pump to draw in air and discharge it into the system as well as cause the fluid to overheat.

c. Care must be used to make sure dirt does not get into the hydraulic fluid. Dirt can cause considerable damage by scratching the machined surfaces of cylinders, pistons, valves, and pumps. So be sure that you don't let dirt get into the hydraulic system when you perform maintenance on it. In addition, when you store hydraulic fluid make sure that it is sealed in its container so that dirt and water are kept out.

15. HYDRAULIC JACKS. Let's study a simple hydraulic jack to see how hydraulic system parts are put together so that they can perform a useful task. Such a jack usually has a reservoir, a reciprocating pump, a single-action cylinder, and a release valve. All the parts are inclosed in one casing, or housing, with the connecting lines being cast or drilled in the jack casing.

a. As shown in the illustration, the reciprocating pump consists of the small piston (A), the cylinder in which the piston is fitted, and two check valves. The single-action cylinder has a large cylinder fitted with a large piston (B) and a ram. The release valve is a needle valve.



b. When the jack handle is raised, fluid is sucked from the reservoir through check valve 1 into the space under piston A. When the handle is pushed down, check valve 1 closes and fluid under piston A is forced through check valve 2 to the area under piston B. This forces piston B and the ram to move up. Fluid cannot drain back through check valve 2, so piston B and the ram are held up when the jack handle is released.

(1) Repeated up-and-down movement of the jack handle will continue to pump fluid from the reservoir to the bottom side of piston B. This raises the ram higher and higher to lift the vehicle or whatever you set the jack under.

(2) Because of the difference in the sizes of piston A and piston B, one long stroke of the jack handle raises the ram just a short distance. This difference, however, provides the mechanical advantage that allows you to lift a heavy vehicle by applying moderate pressure on the jack handle.

(3) To lower the jack ram, all you need to do is to loosen the manually operated release valve. This lifts the valve needle off its seat and allows the weight of the load to push the ram down, returning the fluid trapped under piston B through the release valve and back to the reservoir.

SECTION III. CONCLUSION

16. **SUMMARY.** Liquid confined in a hydraulic system can be used to transmit motion and to increase or decrease forces and motion just as with a mechanical linkage. Tubing and hose can be easily bent and curved in any direction and even coupled to components in motion to deliver liquid under pressure to do work. In many cases, to do the same work with mechanical linkage would require a large number of complicated levers, fulcrums, shafts, and cranks. Any hydraulic system will usually have a reservoir, pump, cylinder or motor, controlling valves, and connecting lines.

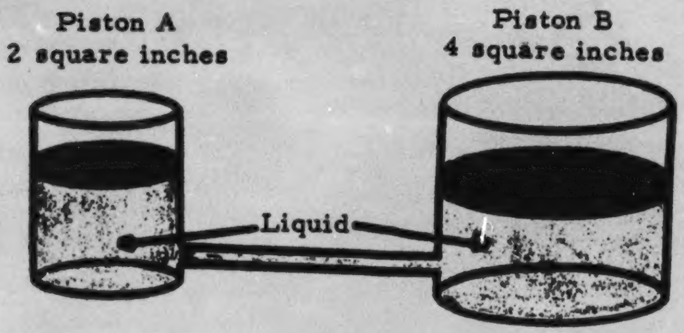
17. **PRACTICE TASKS.** The appendix of this lesson contains a list of tasks associated with the fundamentals of hydraulics. They are the kind of tasks you will have to do as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist who is qualified in the MOS when you practice the tasks. If you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

1. Which statement concerning liquids is true?

   a. Liquids are the only known substances that do not have a shape of their own
   b. It is difficult to transmit force through a liquid if it must follow a winding-path
   c. Liquids can be compressed less than most solids

Note. - Questions 2 through 4 apply to the following illustration.



2. How many pounds of pressure will be exerted on each square inch of piston A if a 200-pound weight is placed on piston B?

   a. 50
   b. 100
   c. 200

3. How many inches will piston A move if piston B is pushed down 2 inches?

   a. 2
   b. 4
   c. 8

4. What is the mechanical advantage ratio of the two pistons?

   a. 1:1
   b. 2:1
   c. 4:1

5. Which hydraulic system part is used to change liquid flow to mechanical movement?

   a. Pump
   b. Valve
   c. Motor

6. Which valve is changed from the fully closed position to the fully open position by rotating its controlling member 1/4 turn?

   a. Globe
   b. Gate
   c. Cock

7. What opens a check valve in a hydraulic system?

   a. Liquid flow
   b. Spring pressure
   c. Gravity

8. Which valve is used to limit the maximum pressure in a hydraulic system?

   a. Check
   b. Regulator
   c. Spool

9. Which factor will have the MOST affect on the amount of liquid pumped by a positive displacement pump in a given time?

   a. The amount of pressure developed
   b. The number of cycles of pump operation that occurs
   c. The viscosity of the liquid being pumped

10. What unit provides a supply of liquid under pressure in addition to the pump?

    a. Regulator
    b. Motor
    c. Accumulator

11. Which pump contains intake and discharge valves?

    a. Reciprocating
    b. Gear
    c. Vane

12. When the hydraulically operated dump bed of a truck is lowered by gravity, the dump bed will most likely be raised by a

    a. double-acting cylinder.
    b. gear-type motor.
    c. single-acting cylinder.

13. When the piston rod of a double-acting cylinder is being extended, liquid is flowing between the rod end of the cylinder and the

    a. pump.
    b. relief valve.
    c. reservoir.

14. What part is constructed almost identical to the hydraulic motor?

    a. Cylinder
    b. Pump
    c. Accumulator

15. What shape is best suited for a hydraulic reservoir on an automotive vehicle?

    a. Tall and slim
    b. Short and wide
    c. Wide bottom and narrow top

16. Which kind of oil should be used in a hydraulic system that contains rubber oil seals?

    a. Mineral
    b. Vegetable
    c. OE

17. The accumulator will discharge liquid into the hydraulic system when

    a. the liquid pressure produced by the pump is increasing.
    b. a sudden demand for liquid exceeds the output of the pump.
    c. pressure output from the pump exceeds the amount required to open the pressure regulator.

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18. Which valve is designed to be left in a partially open position?

   a. Cock
   b. Gate
   c. Needle

19. Condensation is most likely to form in the hydraulic reservoir when the

   a. level of fluid is low.
   b. level of fluid is high.
   c. fluid is too hot.

20. Mechanical advantage is gained hydraulically in a simple hydraulic jack because of the difference in the diameter of the pump cylinder and the

   a. fluid passages.
   b. ram piston.
   c. check valves.

APPENDIX

PRACTICE TASK LIST

Practice Objective . . . . After practicing the following tasks you will be able to:

1. Locate and use hydraulic equipment used in the repair of wheeled vehicles in your work area.
2. Locate hydraulic components in hydraulic systems on wheeled vehicles.
3. Inspect the fluid level and select the correct hydraulic fluids to use in different hydraulic systems of wheeled vehicles.

Practice Tasks.

1. There are probably several examples of hydraulically operated equipment in your unit's maintenance shop. One example, found in any automotive shop, is a hydraulic jack. If your shop repairs wrecked vehicle bodies, it probably also has a hydraulic ram called the Port-a-Power. You may even find a hydraulically operated tester that is used to check the cracking pressure of fuel injector nozzles. Locate and examine all hydraulic equipment your shop may have.

2. Get a hydraulic jack from the toolroom. Check the jack for evidence of leaks. Unless the leak is bad, it probably will not show unless the jack is under load. Locate the reservoir filler plug. Locate the release valve. On small portable jacks this valve usually resembles a screw with a T-bar on the head so it can be turned easily.

3. Position the jack under the axle of a vehicle. Test the operation of the jack by raising and lowering the vehicle.

4. Using the vehicle TM as a guide, locate the following items on a 5-ton wrecker:

   a. Hydraulic brake master cylinder.

   b. Hydraulic power steering reservoir.

c. Power steering pump.

d. Power steering control valve.

e. Power steering piston cylinder.

5. Using the lubrication order for the vehicle as a guide, inspect the hydraulic fluid level in the hydraulic brakes and power steering. Locate the correct fluid to use in each hydraulic system.

6. Using the vehicle TM as a guide, locate the following items on a rough terrain forklift truck:

a. Hydraulic oil tank (reservoir).

b. Hydraulic oil tank filter.

c. Fork tilt cylinder.

d. Forklift cylinders.

e. Oscillation cylinder.

f. Steering cylinders.

g. Hydraulic oil pumps.

h. Hydraulic lines.

7. Using the lubrication order for the forklift truck as a guide, check the oil level in the hydraulic oil tank. Locate the correct fluid to use in the hydraulic system. Note that the fluid type varies, depending on the expected temperatures.

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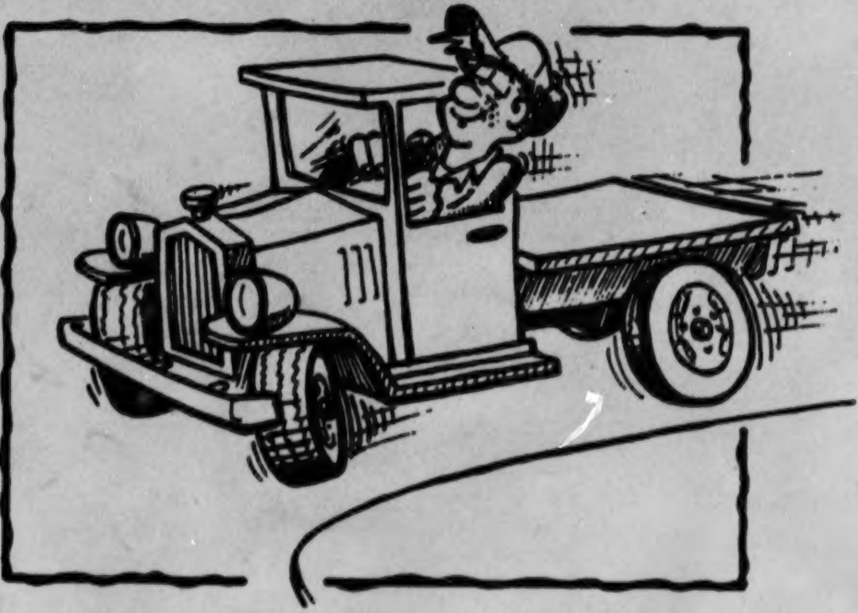
ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B207



LESSON 2

INTRODUCTION TO WHEELED VEHICLE STEERING SYSTEMS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B207 . . . Wheeled Vehicle Steering Systems

Lesson 2 . . . . Introduction to Wheeled Vehicle Steering Systems

Credit Hours . . . . Three

Lesson Objective . . . . After studying this lesson you will be able to:

1. Compare the fifth wheel and Ackerman methods of steering.
2. Describe the steering linkage.
3. Explain how steering gears operate.
4. Describe the worm and sector steering gear.
5. Describe the worm and roller steering gear.
6. Describe the cam and lever steering gear.
7. Describe the worm and ball nut steering gear.
8. Explain the operation of the Ross HP 70 power steering system.

9. Define caster and describe its effect on steering.
10. Define camber and describe its effect on steering.
11. Define kingpin inclination and describe its effect on steering.
12. Define toe-in and explain why it is needed.
13. Define toe-out and explain why it is needed.

Text	Attached Memorandum
Materials Required	Answer sheet and response list
Suggestions	Refer to the illustration.

FOREWORD

One of the most interesting features on wheeled vehicles is the steering system. We usually think of the steering system as all the parts that are necessary to make the front wheels turn in the direction we wish to go. Such parts would include a steering wheel, a gear box, and all linkages and levers needed to control the front wheels.

You will find, however, that the steering system must be carefully designed so that the driver can, without too much effort, keep the vehicle going straight ahead or turn it to the right or left as he wishes. The driver must be able to easily overcome any tendency of the front wheels to go the right or left as a result of striking holes in the road, rocks, stumps, or other obstructions. Such obstructions try to stop the wheel that strikes them, while the other front wheel tries to keep rolling. In such a situation the vehicle would attempt to turn in the direction of the wheel striking the obstruction. This effort by the wheel to change direction is called road shock and it tries to jerk the steering wheel out of the driver's hands. At the very least, hitting obstructions makes it difficult to control the vehicle. Steering systems are designed to reduce the shock caused by striking obstructions.

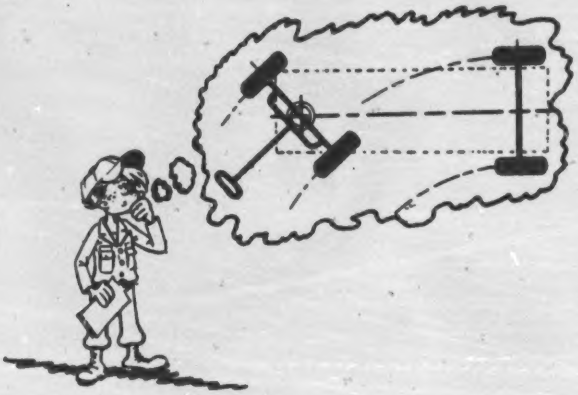
Another feature of the steering system is the front-wheel alinement, which is commonly referred to as steering geometry. Front-wheel alinement can be defined as the proper positioning of the front wheels to make them easy to turn to the right or left and to reduce the tendency of the tires to scuff or wear unevenly. Proper alinement also reduces the tendency of the front wheels to wander or shimmy and makes it much easier to control the vehicle.

ATTACHED MEMORANDUM

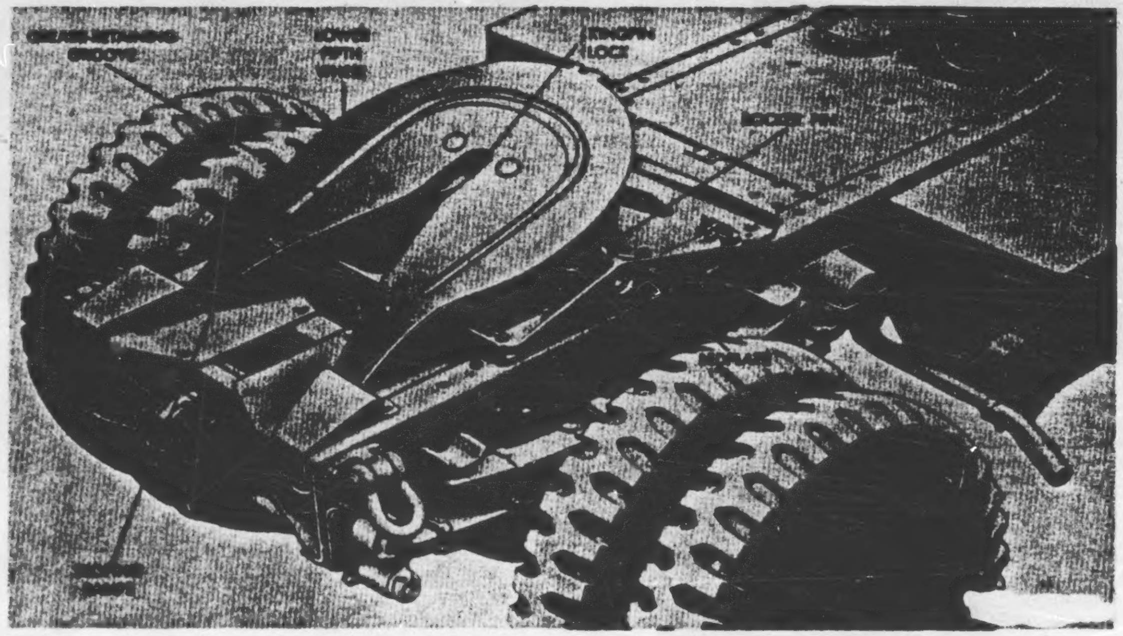
SECTION I. STEERING SYSTEMS

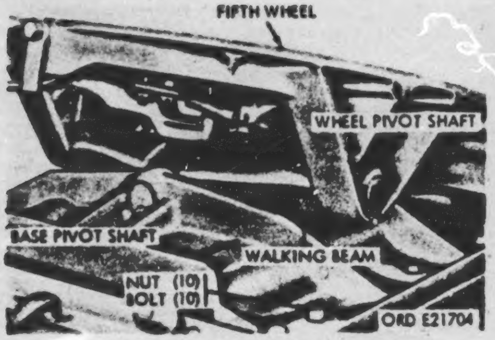
1. FIFTH WHEEL STEERING.

Remember the toy wagon you played with in your younger days? In order to steer the wagon you merely pulled the wagon tongue to the right or left and the axle and both front wheels turned with the tongue. The axle was a single shaft with the wheels mounted on its ends. There was a pivot at the center of the axle so it could be turned to change the wheels from the straight-ahead position. This type of steering arrangemer is known as fifth wheel steering.



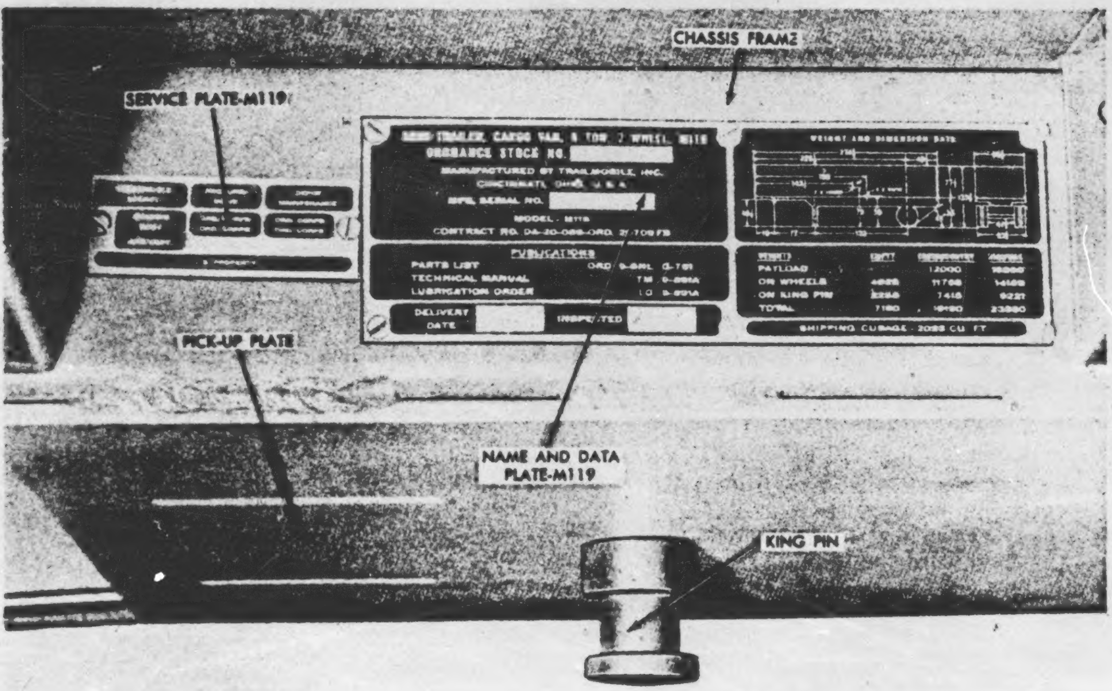
a. Fifth wheel steering is commonly used on towed vehicles such as semitrailers pulled by tractor-trucks. The lower part of the steering pivot or fifth wheel is mounted over the center, and slightly to the front, of the rear axle of the tractor. It has a kingpin lock to hold the kingpin or pivot pin of the semitrailer in the center of the fifth wheel.



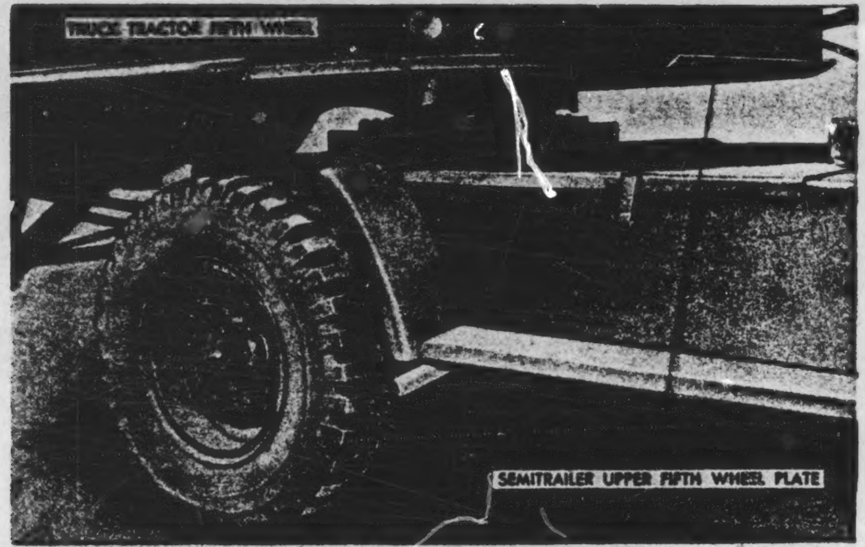

FIFTH WHEEL
WHEEL PIVOT SHAFT
BASE PIVOT SHAFT
WALKING BEAM
NUT (10)
BOLT (10)
ORD E21704

(1) Usually the lowe[illegible]fth wheel is mounted on the tracto[illegible] two pivot shafts. One shaft is [illegible]tioned crosswise to the tractor; the other lengthwise. This allows the lower fifth wheel to tip at various angles to the tractor chassis, keeping the bearing surfaces of upper and lower halves of the fifth wheel in firm contact as the tractor and trailer travel over unlevel roads.

(2) The upper part of the fifth wheel consists of a pickup plate and kingpin secured to the bottom front of the semitrailer. A groove around the kingpin allows engagement of the kingpin lock.

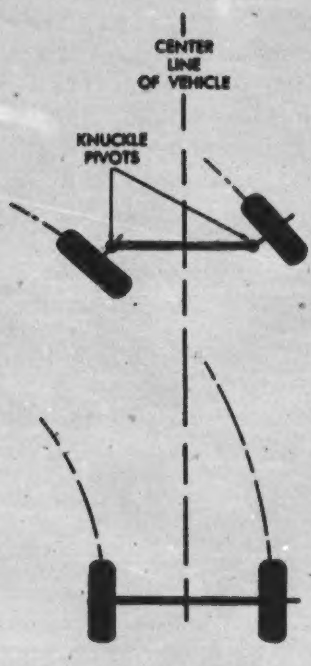

CHASSIS FRAME
SERVICE PLATE-M119
PICK-UP PLATE
NAME AND DATA PLATE-M119
KING PIN

b. It should be noted that when the semitrailer is connected to the tractor, the bottom of the trailer is higher than the tractor wheels. This is necessary because as the truck and trailer make a turn, the entire rear axle and wheel assembly pivot under the front of the trailer frame just as it did on your toy wagon. If the turn is sharp enough, the wheel on the inside of the turn will move to about the middle under the trailer chassis; so clearance must be provided for the wheel.


TRUCK TRACTOR FIFTH WHEEL
SEMITRAILER UPPER FIFTH WHEEL PLATE

FIFTH WHEELS

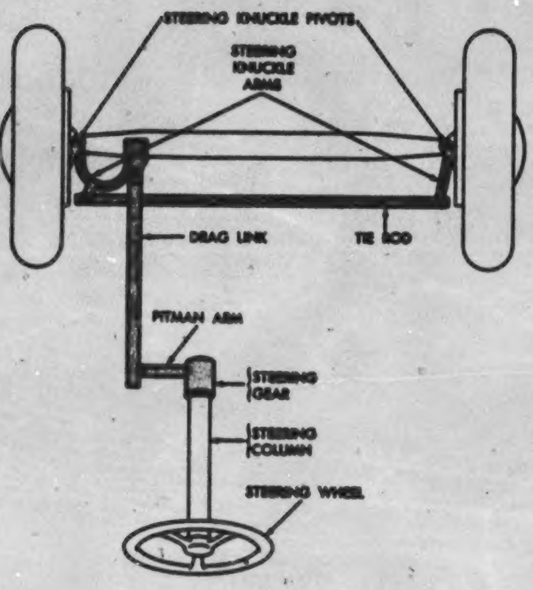
2. ACKERMAN STEERING. Obviously, the fifth wheel method of steering is not suitable for use in steering a modern car or truck. The vehicle chassis would have to be too high off the ground to provide clearance for the front wheels. Cars and trucks use a front wheel arrangement that is called the Ackerman steering method.



a. With this arrangement the axle is held at right angles to the vehicle frame and cannot pivot. The wheels can be changed from the straight-ahead position independently on separate pivot pins or knuckle pivots at the ends of the axle.

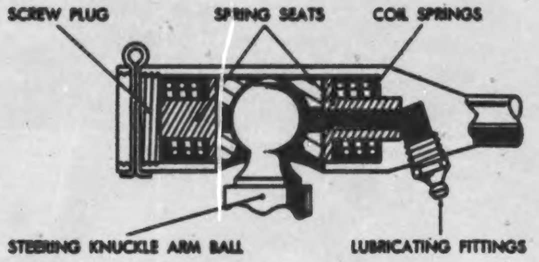
b. We will be discussing the Ackerman steering method throughout the remainder of this lesson, so let's clarify a couple of terms that we will be using in regard to wheel movements with this method. When we say "the wheels pivot," we mean that they are changed in relation to the straight-ahead position as they are when making a right or left turn. When we say "the wheels rotate," we mean that they turn on their spindles as they do when the vehicle rolls forward or backward.

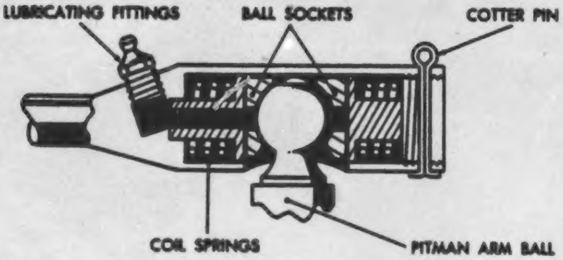
3. STEERING LINKAGE. In order to make a turn, the driver of a car or truck merely turns the steering wheel to the right or left, depending on the direction he wants to turn. Because each front wheel has its own separate steering pivot, a considerable amount of linkage is needed to transfer the steering wheel movements to both wheels. The steering wheel is located at the top of a steering column, and as it is turned a steering gear at the bottom of the column is operated. The steering linkage can be described as all of the levers, rods, arms, and links used to connect the steering gear to the front wheels. There is a wide variation in the amount of steering linkage used due to the difference in design of the many vehicle models.


STEERING KNUCKLE PIVOTS
STEERING KNUCKLE ARMS
DRAG LINK
TIE ROD
PITMAN ARM
STEERING GEAR
STEERING COLUMN
STEERING WHEEL

a. Most vehicles with front axle suspension have a steering linkage arrangement like the one shown in the accompanying illustration. The linkage consists of the pitman arm, which is splined to the output shaft or pitman arm shaft of the steering gear; the drag link, which links the pitman arm to the steering knuckle arm of the left front wheel; two steering knuckle arms, one secured to each of the front-wheel spindles; and the tie rod, which links the two front-wheel steering arms together. The linkage may be arranged so that the tie rod is in front of the axle instead of behind it.

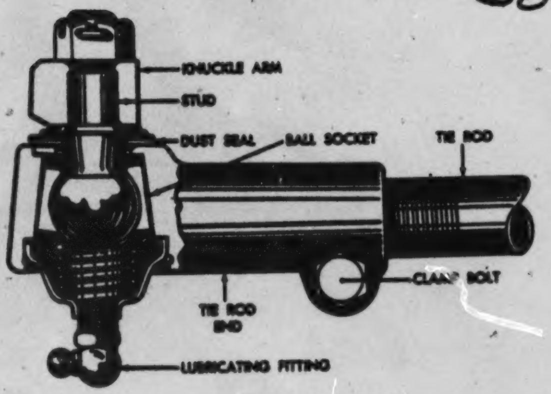
(1) Turning the steering wheel back and forth causes the pitman arm shaft to rotate back and forth. This swings the pitman arm in an arc so that the drag link moves back and forth in a straight line. The drag link transmits the movement to the left steering arm to pivot the left wheel spindle and wheel back and forth on the steering knuckle pivots. Pivot movements of the left wheel are transmitted to the right wheel by the tie rod.


SCREW PLUG
SPRING SEATS
COIL SPRINGS
STEERING KNUCKLE ARM BALL
LUBRICATING FITTINGS


LUBRICATING FITTINGS
BALL SOCKETS
COTTER PIN
COIL SPRINGS
PITMAN ARM BALL

(2) The drag link and tie rod are fastened to the pitman and steering arms by a joint that permits a swiveling action. The adjustable ball socket is one type of joint that is commonly used on the drag link. Ball type studs are secured to the pitman arm and the left steering arm. A housing is provided at each end of the drag link to receive the balls. Ball sockets, coil springs, spring seats, and a screw plug are inserted into the housings to hold the balls. The screw plug can be screwed in or out to tighten or loosen the joint. Lubrication fittings are provided for each joint. Shields are located at the points where the ball studs enter the housings to hold the lubrication in and to keep dirt out.

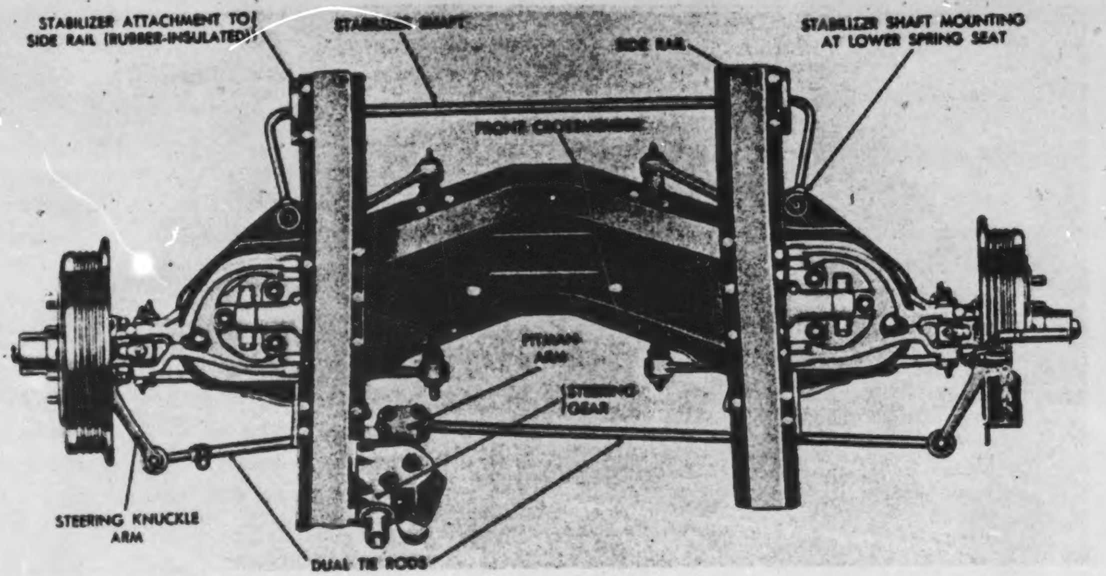
(3) The tie rod also makes use of ball and socket type joints, but generally they are made so that they cannot be adjusted. A spring holds the ball in its seat to prevent slack. The ball of a tie rod end has a tapered shank or stud that fits into a matching tapered hole in the steering arm. The end of the ball stud is threaded and drilled so it can be secured to the steering knuckle arms with a nut and cotter key.


KNUCKLE ARM
STUD
DUST SEAL
BALL SOCKET
TIE ROD
CLAMP BOLT
TIE ROD END
LUBRICATING FITTING

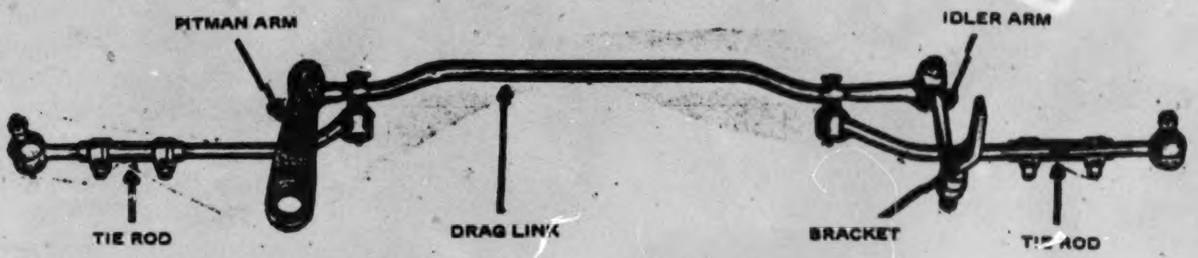
(a) Each tie rod end is threaded and is screwed onto threaded ends of the tie rod. A clamp bolt is provided to prevent the tie rod from turning on the threads of the tie rod end once the ends have been installed.

(b) One tie rod end and one end of the tie rod have left-hand threads, while the other tie rod end and the opposite end of the tie rod have right-hand threads. This is so the overall length of the tie rod assembly can be adjusted when alining the front wheels without disconnecting either tie rod end.

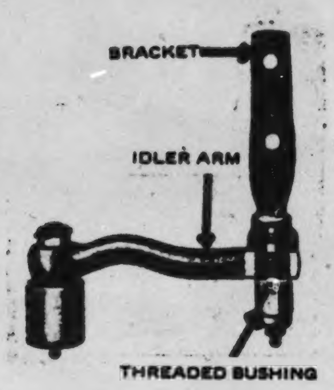
b. If the vehicle has independent front-wheel suspension instead of an axle, the steering linkage arrangement is a lot different. Two tie rods are required so one wheel can raise and lower without affecting the steering of the other wheel. Many different linkage arrangements are used with independent suspension. Some are quite simple, with the linkage consisting of no more than the pitman arm, two tie rods, and the steering arms.


STABILIZER ATTACHMENT TO SIDE RAIL (RUBBER-INSULATED)
STABILIZER SHAFT
SIDE RAIL
STABILIZER SHAFT MOUNTING AT LOWER SPRING SEAT
FRONT CROSSMEMBER
PITMAN ARM
STEERING GEAR
STEERING KNUCKLE ARM
DUAL TIE RODS

(1) Other common arrangements add an idler arm and drag link. In these arrangements the idler arm is mounted on the right frame rail by a bracket so it sets parallel to the pitman arm. The drag link connects the pitman arm and idler arm so that moving the steering wheel causes both arms to swing in the same arc. Each steering arm is linked to the drag link by a separate tie rod. In this arrangement the drag link may be referred to by different names, such as relay rod, pitman arm-to-idler arm rod, etc.



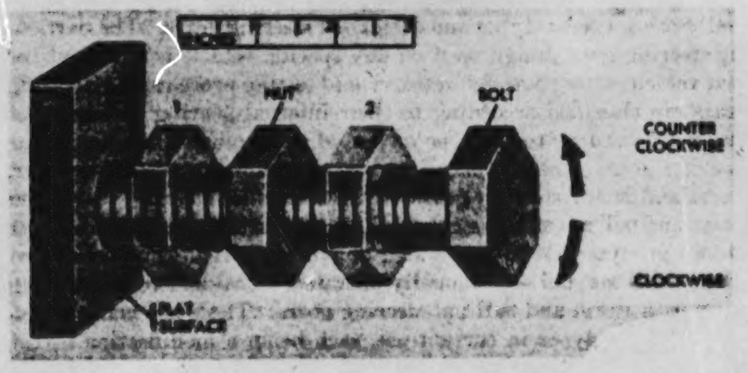
(2) Usually the length of both tie rods is adjustable so that they can be adjusted independently when alining the front wheels. The ends on the drag links and tie rods in vehicles with independent wheel suspension are usually the non-adjustable ball and socket type. The ends are equipped with lubricating fittings on most vehicles, but on some late model cars they are lubricated for life when manufactured, so will not contain lubricating fittings.



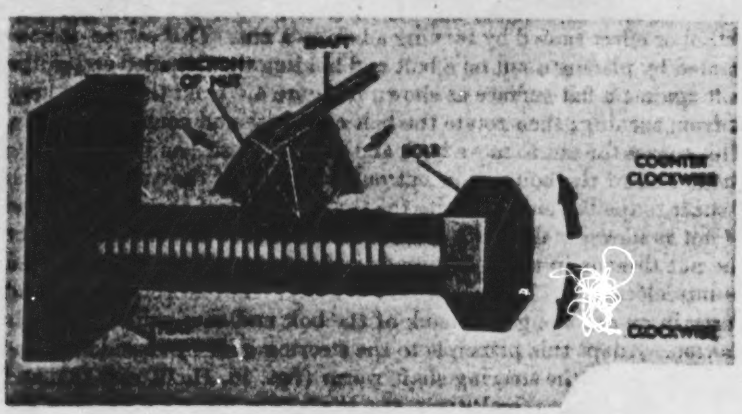
(3) Either threaded or rubber-type bushings may be used at the idler arm-to-idler arm bracket pivot. If the threaded-type bushing is used, the bushing contains both internal and external threads. The external threads are generally right-hand threads and are screwed into, and tightened in, a threaded hole in either the idler arm or its bracket. The internal threads are generally left-hand threads and are screwed onto the threaded end of the arm or bracket until it bottoms and then is backed up 1/2 to 1 turn. This leaves the idler arm free to pivot on the inner threads of the bushing.

4. **STEERING GEAR PRINCIPLES.** If the steering wheel was coupled directly to the pitman arm by a shaft, it would be very hard for the driver to steer the vehicle. Something must be used between the steering wheel and pitman arm so the driver can gain a mechanical advantage to make steering easier. This is provided by the steering gear.

a. The principles of steering gears can be demonstrated with a bolt and a nut in the following manner. Screw the nut to the midpoint of the threads on the bolt. Place the end of the bolt against a flat surface so it cannot move back and forth but can be rotated. Hold the nut so it cannot rotate; then turn the bolt. When the bolt is turned clockwise the nut is pulled toward the bolt's head. When the bolt is turned counterclockwise the nut will be moved away from the bolt's head.



b. Now, if we cut out a section of the nut, attach a shaft to it, and place it against the bolt, we can see how this principle is used in the steering gear. With this arrangement, turning the bolt back and forth will cause the nut section to swing back and forth, turning the shaft with it.

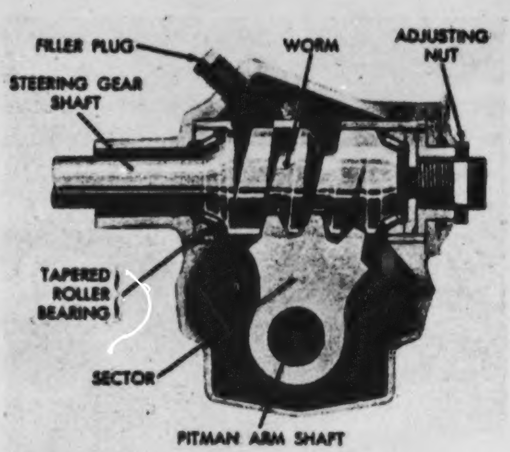


(1) In a steering gear the part that is like the bolt is called the worm. The worm is secured to the lower end of a shaft with the steering wheel on the opposite end of the shaft so that the worm and steering wheel turn together. The steering gear part that is like the section of a nut is called the sector and its shaft is called the pitman arm shaft. The pitman arm is splined to the pitman arm shaft.

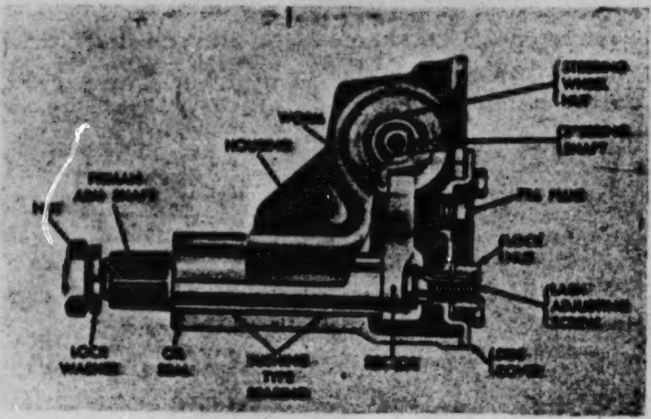
(2) The steering gear worm (bolt) and the sector (nut section) are machined so that they have very little lash or clearance between their threads in the midposition. However, as the worm is turned to steer the vehicle either to the right or the left, the amount of lash gets greater. This makes up for unequal wear that occurs in normal use. Vehicles are operated in the straight-ahead position most of the time, so most of the wear is in the center of the steering gear worm.

(3) It requires 2-1/2 to 3-1/2 turns of the steering wheel and worm to move the pitman arm shaft through its entire allowable movement, which is an arc of about 70 degrees. That will pivot the front wheels from a hard turn in one direction to a hard turn in the opposite direction. The steering wheel has to be turned farther because of the mechanical advantage gained by the worm and sector. Most steering gears are designed so that they provide more mechanical advantage in the midposition than when turned to the extreme right or left, so they are said to have a variable ratio. Many different kinds of steering gears are used, but they all work in about the same manner. In the next four paragraphs we will take a look at some of the different types of steering gears.

5. WORM AND SECTOR STEERING GEAR. This type of steering gear looks a lot like our bolt and nut steering gear. Often the sector of this type is compared to a gear instead of a nut. The teeth of the sector are machined in an arc, or curve, so that they actually look like a section of a gear.



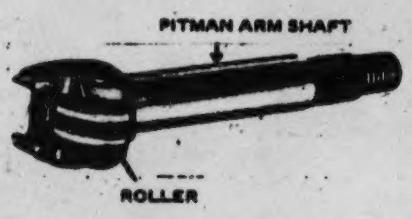
a. As the steering wheel and worm turn, the worm pivots the sector and pitman arm shaft. The sector can only pivot through an arc of 70° because it is stopped at each extreme by the sector touching the steering gear housing.

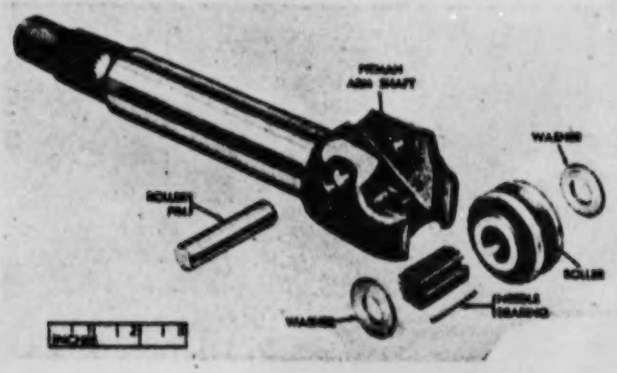

STEERING WHEEL NUT
STEERING SHAFT
WORM
HOUSING
PITMAN ARM SHAFT
NUT
FIL PLUG
LOCK NUT
LASH ADJUSTING SCREW
LOCK WASHER
OIL SEAL
BUSHING TYPE BEARING
SECTOR
SIDE COVER

b. The worm is assembled between bearings, with some means provided for adjusting the bearings to control worm end play. The pitman arm shaft is fitted into the steering gear housing on bearings which are generally the bushing type, but roller-type bearings are sometimes used. A lash adjustment screw is also provided so that the sector can be moved closer to, or farther away from, the worm gear to control the amount of backlash between the sector and worm threads or teeth.

c. The worm and sector steering gear is very simple in construction, which makes it cheap to build and easy to maintain. A disadvantage is that it has a lot of friction due to the sliding action between the worm and sector gear teeth.

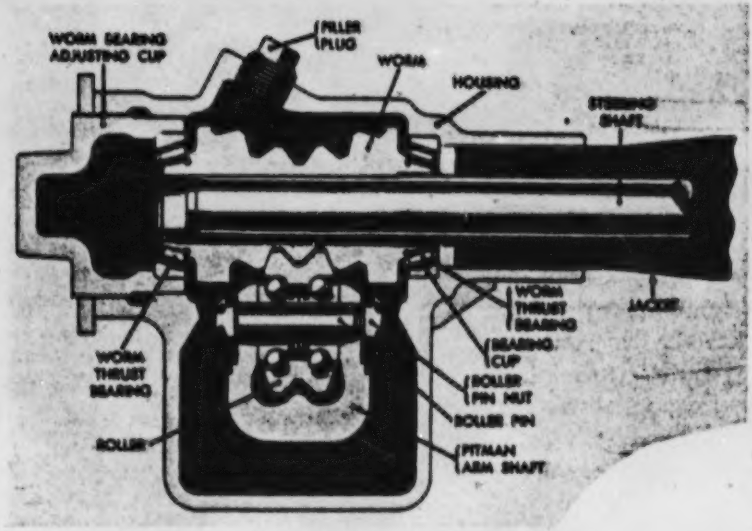
6. WORM AND ROLLER STEERING GEAR. The worm and roller steering gear is much like the worm and sector, but it changes the sliding friction to rolling friction so that less effort is required to turn the steering wheel. This is made possible by machining the sector teeth on a roller.

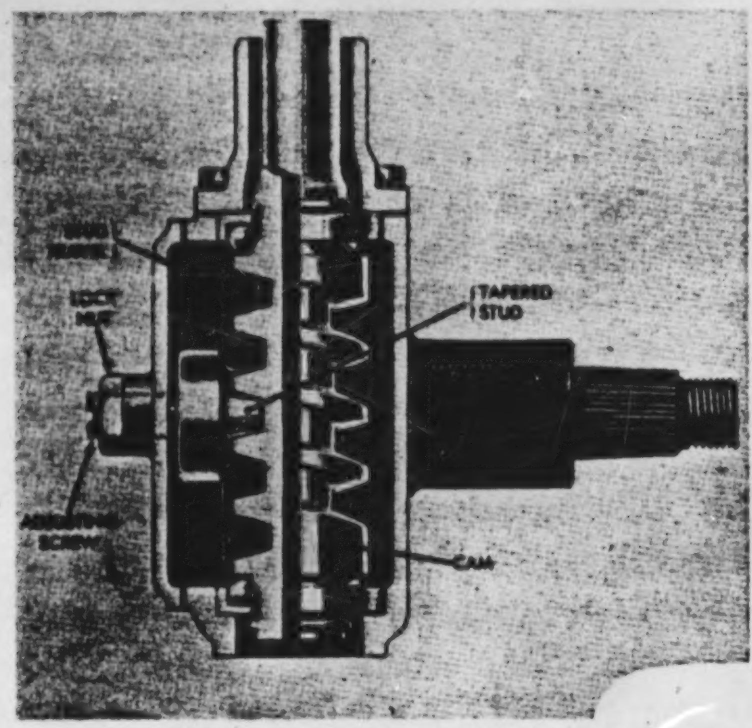

PITMAN ARM SHAFT
ROLLER


PITMAN ARM SHAFT
WASHER
ROLLER PIN
ROLLER
NEEDLE BEARING
WASHER
INCHES

a. Friction is reduced even more by mounting the roller on bearings in a saddle at the inner end of the pitman arm shaft.

b. The worm has an hourglass shape; that is, the worm is smaller in the center than at both ends. The reason for cutting the worm in an hourglass shape is so that the roller will stay in better contact with the worm teeth at the ends of the worm.

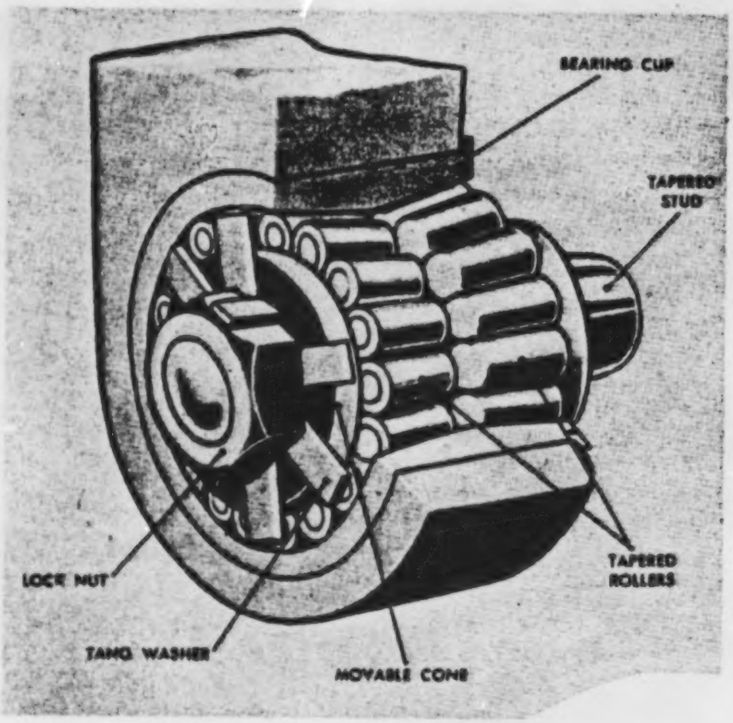

WORM BEARING ADJUSTING CUP
FILLER PLUG
WORM
HOUSING
STEERING SHAFT
WORM THRUST BEARING
JACKET
BEARING CUP
WORM THRUST BEARING
ROLLER PIN NUT
ROLLER PIN
ROLLER
PITMAN ARM SHAFT

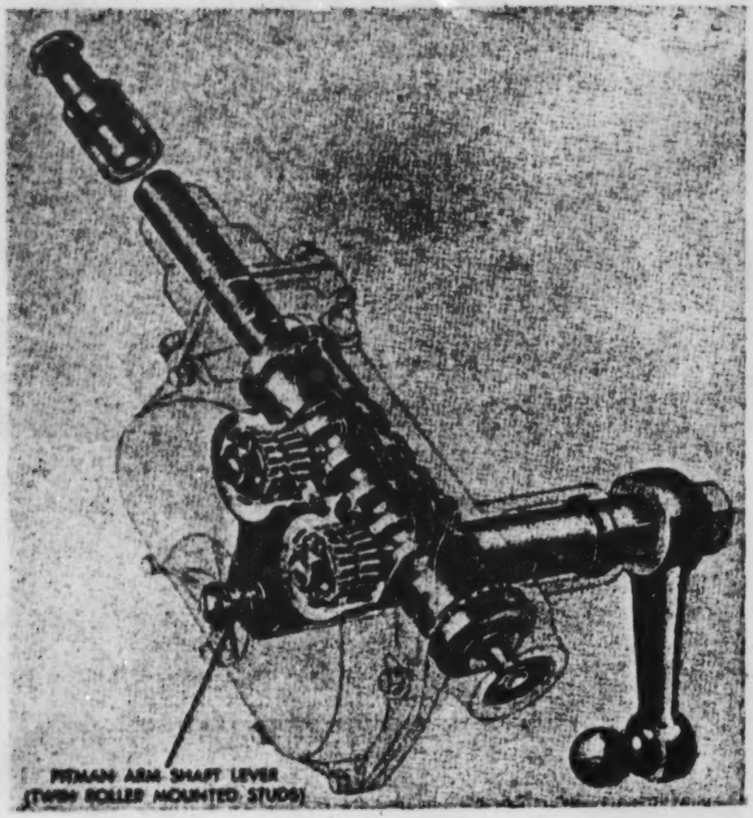

LOCK NUT
ADJUSTING SCREW
TAPERED STUD
CAM

7. CAM AND LEVER STEERING GEAR.

In the cam and lever steering gear, the worm is known as a cam. The inner end of the pitman arm shaft has a lever that contains a tapered stud. The stud engages in the cam so that the lever will be moved back and forth when the cam is turned back and forth.

a. When the tapered stud is fixed in the lever so that it can't rotate, there is sliding friction between it and the cam. Therefore, on some vehicles using this type of steering gear, the stud is mounted in bearings so that it can roll in the cam groove (threads) instead of sliding.

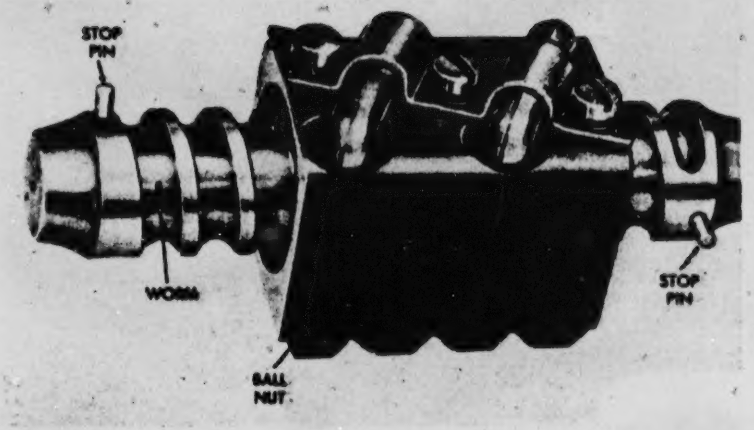

BEARING CUP
TAPERED STUD
TAPERED ROLLERS
LOCK NUT
TANG WASHER
MOVABLE CONE



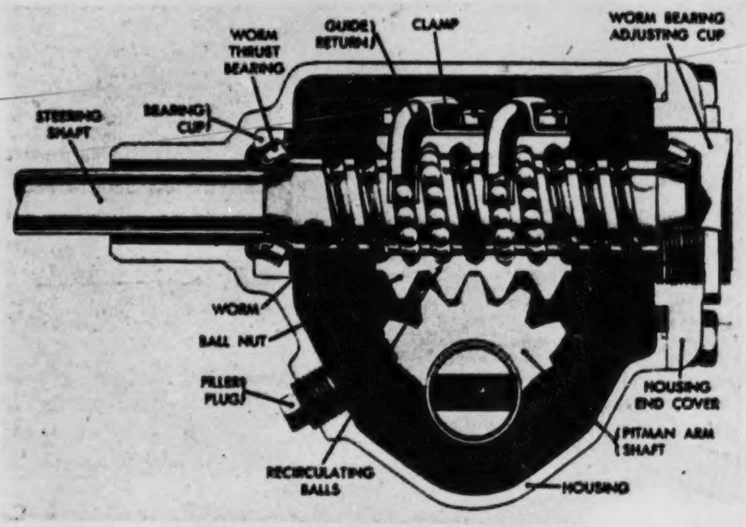
b. Some large trucks use a cam and twin lever steering gear. This is nothing more than a cam and lever gear with two tapered studs instead of one. The studs may be fixed in the lever or they may be mounted on bearings.

8. WORM AND BALL NUT STEERING GEAR. Another form of steering gear is called the worm and ball nut. In its operation this one really acts like a bolt and a nut. A nut is meshed with the worm and screws up and down when the worm is turned back and forth.

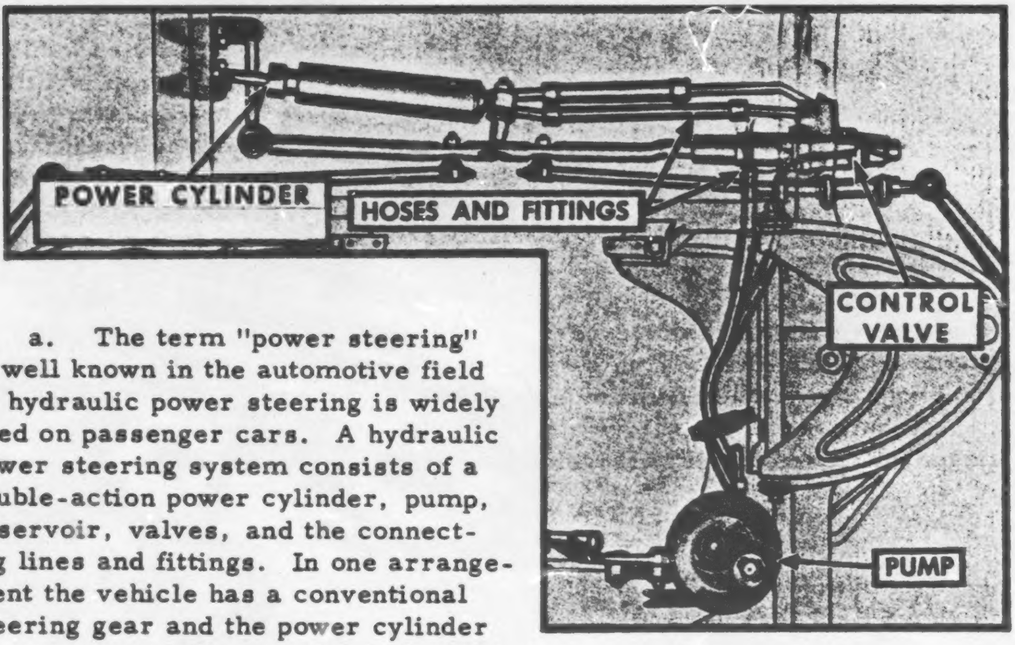
a. These steering gears are also commonly called the recirculating ball type. Both the nut and the worm have round-shaped threads so steel balls can fit in them and act as a bearing to reduce the friction between the worm and nut. Ball guides on one side of the nut allow the balls to recirculate as the worm is turned to screw the nut back and forth on the worm.


STOP PIN
WORM
BALL NUT
STOP PIN

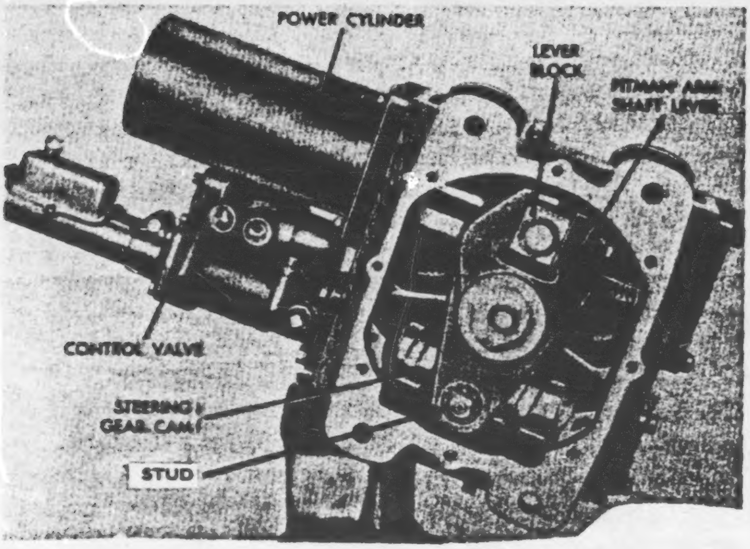
b. The nut has teeth on one side that mesh with the sector and turn the pitman arm shaft back and forth as the nut is moved back and forth. As with all the rest of the steering gears we have described, the end play of the worm and the backlash between the nut and sector teeth are adjustable.


WORM THRUST BEARING
GUIDE RETURN
CLAMP
WORM BEARING ADJUSTING CUP
STEERING SHAFT
BEARING CUP
WORM
BALL NUT
FILLER PLUG
RECIRCULATING BALLS
HOUSING END COVER
PITMAN ARM SHAFT
HOUSING

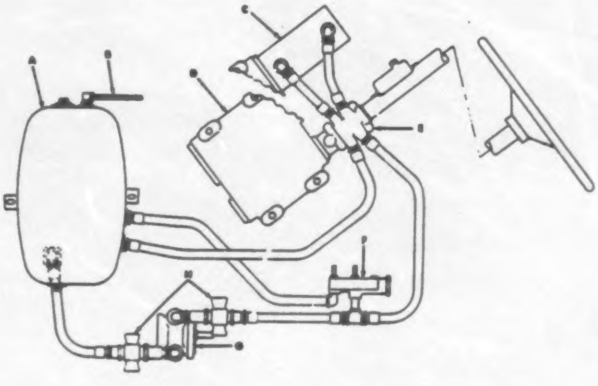
9. POWER STEERING. Steering gears provide a mechanical advantage ratio of 11 or 12:1 for light cars and up to 18:1 or more for heavy trucks. Often more mechanical advantage is desired to make some heavy vehicles easier to steer. This is not practical though as it would require an excessive amount of turning at the steering wheel to pivot the front wheels. In order to reduce the amount of effort required to turn the wheels without increasing the amount that the steering wheel is turned, power steering is used.



a. The term "power steering" is well known in the automotive field as hydraulic power steering is widely used on passenger cars. A hydraulic power steering system consists of a double-action power cylinder, pump, reservoir, valves, and the connecting lines and fittings. In one arrangement the vehicle has a conventional steering gear and the power cylinder is connected to the steering linkage so it will assist in moving the linkage. A spool type control valve is located in the drag link and operated by pitman arm movement. Hydraulic pressure is supplied by the pump, which is belt-driven from the engine.



b. In another common power steering arrangement the power cylinder and control valve operate from, and give power assist directly to, the steering gear assembly. The power steering used on the Army's 5-ton, 6x6 trucks is such an arrangement. The 5-ton trucks have the Ross model HP 70 steering gear. The steering gear is the cam-and-lever type. The pitman arm shaft is attached to the center of the lever. The tapered stud is mounted on bearings in the lever's lower end and engages the steering gear cam. The upper end of the lever is slotted to receive a lever block on the power cylinder piston rod. The control valve and power cylinder are mounted on the steering gear housing.



Key		Key	
A	Oil reservoir	E	Hydraulic control valve
B	Vent line	F	Relief valve assembly
C	Power cylinder assembly	G	Hydraulic pump assembly
D	Steering gear housing	H	Self-sealing couplings

(1) The complete HP 70 hydraulic system of the 5-ton truck includes the oil reservoir, the power cylinder, hydraulic control valve, relief valve, pump, and connecting lines. The engine driven pump draws oil from the reservoir through the suction line and discharges it into the pressure line. Oil under pressure first flows to the relief valve, which is bolted to the steering gear housing. The relief valve is set to limit the pressure to 750 PSI. Excess pressure is released through a line from the relief valve to the reservoir. The pressure line from the relief valve delivers oil to the control valve. The control valve directs oil to and from the power cylinder and to the reservoir to control the system.

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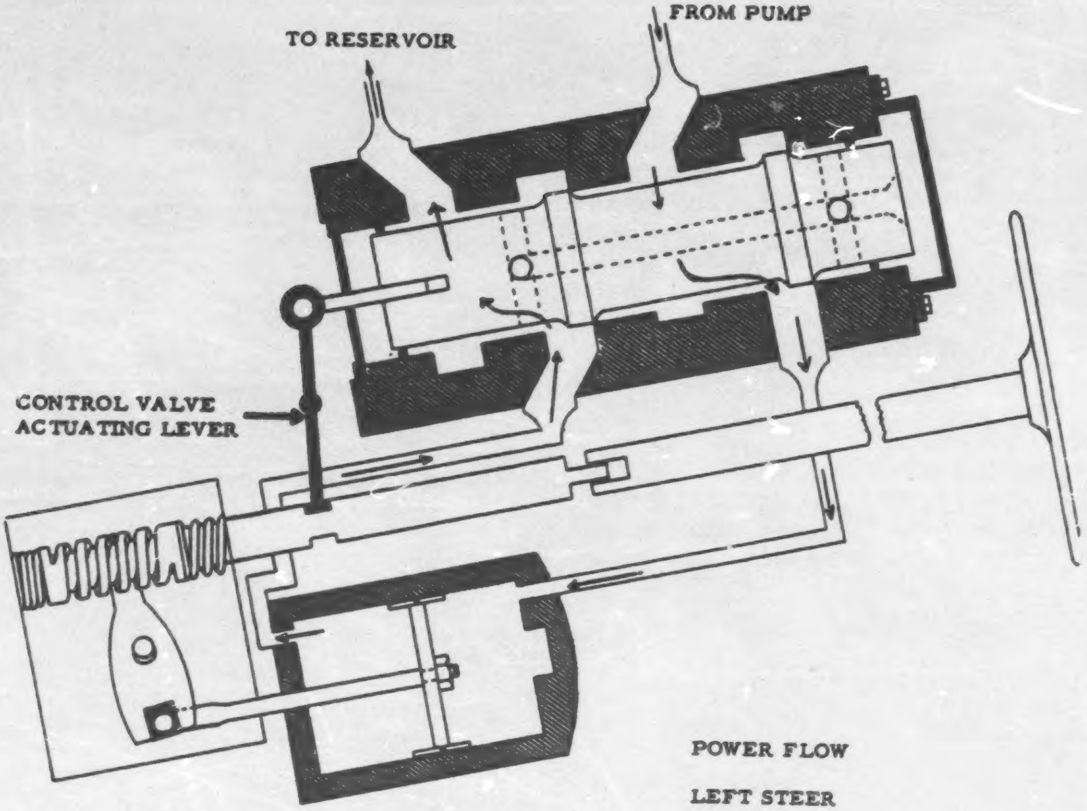
(4) Suppose that the driver turns the steering wheel to make a left turn. The cam will try to move endwise to the left as it exerts pressure on the stud. This compresses the spring at the lower end of the cam, and the cam moves to the left. The control valve lever pivots, moving the control valve to the right.



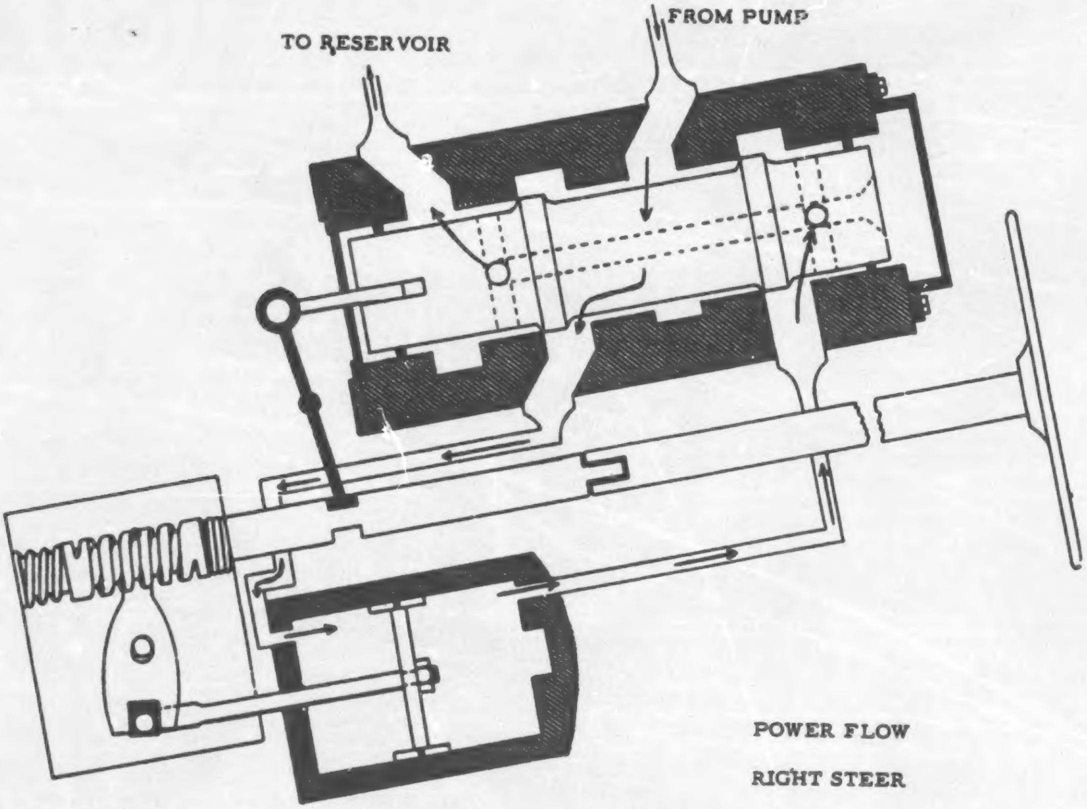
POWER FLOW

LEFT STEER

(a) The shoulders of the spool control valve now block the oil flow from the pump to the reservoir and to the left side of the power cylinder piston. However, a passage is left open that allows the pump to force oil through the valve to the right side of the power cylinder piston, which pushes the piston to the left. The mechanical force exerted by the cam on the stud at one end of the lever and the hydraulic power cylinder piston pushing on the lever at its opposite end now work together, applying pressure directly to the lever to turn the pitman arm shaft.

(b) As the driver continues to turn the steering wheel to the left, the pitman arm shaft continues to pivot and the power cylinder piston moves to the left. Oil on the left side of the piston is returned to the reservoir through the control valve. As soon as the driver stops the turning effort on the steering wheel, the compressed spring on the bottom of the cam expands, moving the cam and control valve back to the neutral position.

(5) When the steering wheel is turned for a right turn, the endwise movement of the cam is to the right, compressing the spring at the upper end of the cam. The control valve is moved to the left and directs oil from the pump to the left side of the power cylinder. A power assist is now furnished for a right turn. Oil that is being pushed from the right side of the cylinder passes through the passage in the drilled center of the control valve and returns to the reservoir.



POWER FLOW

RIGHT STEER

(6) As long as the driver is turning the steering wheel, the power cylinder will assist him. The instant he stops the turning effort the springs at the ends of the cam return the control valve to the neutral position and the power assist stops. The driver is in full control at all times because the power assist operates only when the driver exerts a turning effort on the steering wheel.

(7) The amount of pressure developed in the system at any given time depends on the amount of resistance offered to oil flow. The resistance varies according to the steering situation. When the control valve is in the neutral position, oil flows freely back to the reservoir so very little pressure will be developed.

(a) When the driver turns the steering wheel and oil is directed to the power cylinder, pressure will increase. If the vehicle is moving it is fairly easy to turn, so the cylinder piston moves readily with fairly low hydraulic pressure. Just enough pressure is developed to move the piston.

(b) If the truck is not moving when turning the steering wheel, the front wheels are extremely hard to pivot. In this case, a high hydraulic pressure will be developed before the power cylinder piston moves.

(c) If it is not possible to pivot the wheels, such as when they are in ruts or up against the curb, the hydraulic pressure will build up to the setting of the relief (regulator) valve. At this point, the relief valve will open and bypass the excess oil to the reservoir to prevent damage to the system.

(8) Power steering also acts to reduce the amount of road shock transmitted to the steering wheel. When a front wheel hits a bump or a hole in the road, it tries to stop or turn in another direction. The wheel's movement is transmitted through the linkage and steering gear to the steering wheel. On big trucks this movement can be so bad that it may jerk the steering wheel from the driver's hands. Here is how power steering reduces this action.

(a) When the front wheel hits a bump, it cannot turn the power steering gear very quickly because it must move the power cylinder piston, too. With oil on each side of the piston, the power cylinder works much like the shock absorber does on the suspension. Besides acting like a shock absorber, power steering works in another way to reduce road shock.

(b) When road shock causes the front wheel to move the steering linkage and steering gear lever, the lever stud pushes on the cam. This causes an endwise movement of the cam and moves the control valve from the neutral position. Oil from the pump is then directed to the side of the power cylinder piston that will resist the movement. In this manner, the power cylinder will always be working with hydraulic pressure to oppose any movements caused by road shock.

SECTION II. PRINCIPLES OF WHEEL ALINEMENT

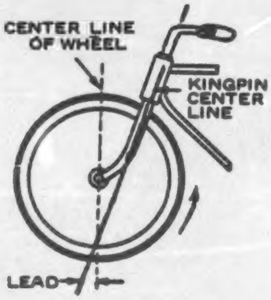
10. GENERAL. It is not enough to merely place the front wheels on spindles and steering knuckles so they can roll and so the driver can pivot them to the right or left. The wheels must be pointed or alined just right if the vehicle is to steer properly.

a. Wheel alinement, or steering geometry as it is sometimes called, is the positioning of the front wheels to best control or assist such forces as gravity, friction, momentum, and centrifugal force. All of these forces tend to make steering difficult.

b. Perfectly alined wheels should not have the tendency to wander, weave, shimmy, or scuff tires, yet they should be easy to pivot when making a turn. In addition, the front wheels should straighten out if the driver releases the steering wheel after turning a corner.

c. To do all this, the front wheels and their pivot points are not positioned straight up and down or straight ahead. They are tilted at various angles. There are five different angles involved in the alinement of the front wheels. They are called caster, camber, kingpin inclination, toe-in, and toe-out. Definitions of these angles and the effect they produce are given in the following paragraphs.

11. CASTER. If you have ridden a bicycle you probably noticed that the fork in which the front wheel was mounted was tilted backward at the top. A straight line drawn down through the front-wheel pivot or kingpin would strike the ground ahead of the point where the tire contacts the road. A wheel mounted in this fashion is said to have positive (+) caster or just caster. If the top of the kingpin is tilted forward so a straight line drawn through it will hit behind the point where the tire contacts the ground, the wheel is said to have negative (-) caster.



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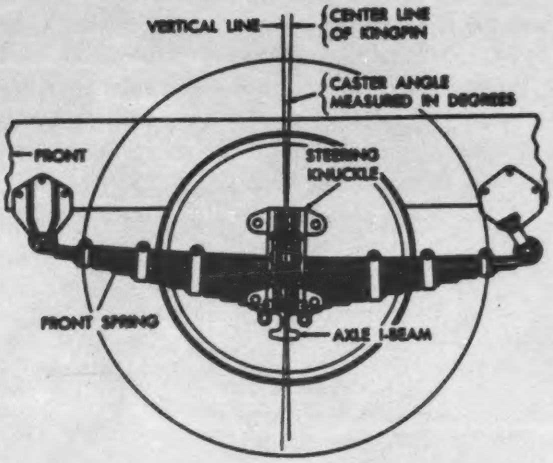


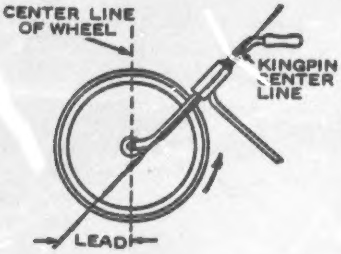
a. On a vehicle with axle suspension, caster is obtained by the axle being mounted so that the top of the steering knuckle or kingpin is tilted to the rear. On independent suspension the upper pivot point is set to the rear of the lower pivot point.

(1) The caster angle is measured in degrees. The angle is shown by drawing one line straight up and down and then drawing a second line through the center of the kingpin or pivot points. The caster angle is the angle formed at the point where the two lines cross as viewed from the side of the vehicle.

(2) From the above description of caster we can say that caster or positive caster is the backward tilt of the kingpin at the top. Negative caster is just the reverse, with the kingpin tilted forward at the top.

b. Positive caster causes the vehicle to steer in the direction that it tends to go. This is called an automatic steering effect. For instance, the forward momentum of a vehicle tends to keep wheels with positive caster in the straight-ahead position. After rounding a turn, this causes the wheels to return to a straight-ahead position if the driver releases the steering wheel. This automatic steering effect is also called self-righting action or self-centering action.

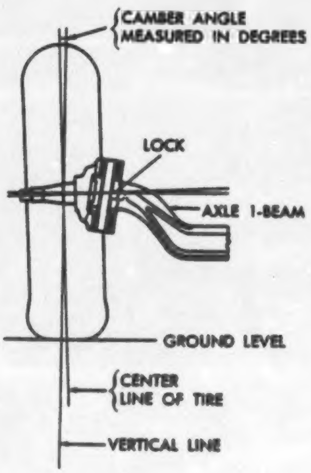
(1) The automatic steering effect of caster can be shown by picturing a bicycle with an excess amount of caster. As the wheel is pushed forward it resists movement, so it pulls back at the point where it contacts the road. Since the kingpin is pointed in front of the tire contact, the wheel pulling back tends to keep it in the straight-ahead position.

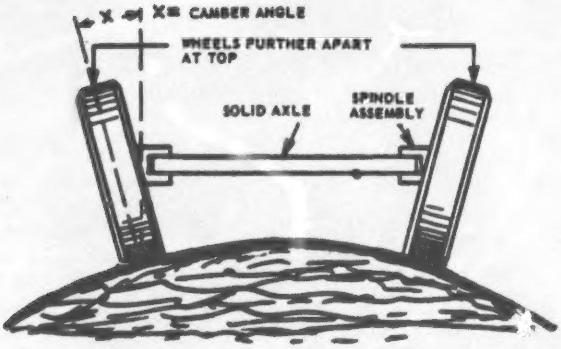


CASTER ANGLE (EXAGGERATED)

(2) Forces other than forward momentum also react with caster so that the automatic steering is not always perfectly straight ahead. Any force that is pushing on the side of the vehicle tends to pivot the wheels in the direction of the force. For this reason, positive caster tends to cause a vehicle to steer down off a crowned road and in the direction of a crosswind. Some passenger cars are designed to have negative caster so that just the opposite will happen; that is, they will tend to steer up a crowned road and against or into a crosswind.

12. CAMBER. The camber angle is determined by viewing the wheels from the front. If the wheels are tilted out at the top, they have positive camber. If they are tilted in, they have negative camber. The camber angle is measured in degrees. It is shown by drawing one line through the center of the wheel and then drawing a second line straight up and down so that it crosses the first. Camber is obtained by having the wheel spindle pointed downward at the outer end.

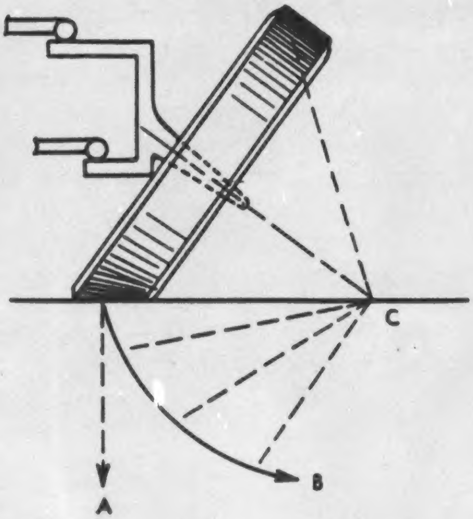

CAMBER ANGLE MEASURED IN DEGREES
LOCK
AXLE I-BEAM
GROUND LEVEL
CENTER LINE OF TIRE
VERTICAL LINE

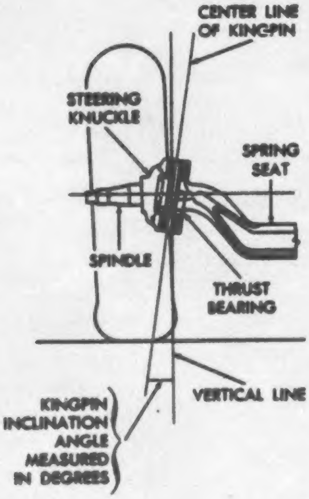

X
X= CAMBER ANGLE
WHEELS FURTHER APART AT TOP
SOLID AXLE
SPINDLE ASSEMBLY

a. Originally roads were built with a high crown; that is, they were high in the middle and sloped downward to the sides. A large amount of positive wheel camber was needed so that the tire would contact the road squarely. If the tire does not set squarely on the road, it will wear on one side and will not get a good grip for positive steering control. Modern roads, however, are made flat with very little crown, so very little camber is needed for this purpose on modern vehicles.

b. Some camber is generally desirable, even with flat roads, because it moves the point of contact between the tire and the road more directly under, and closer to, the steering knuckle pivot. This makes the wheels easier to pivot and reduces the amount of road shock that is sent to the vehicle suspension and steering linkage when the wheels hit bumps. It also places most of the load on the large inner wheel bearing.

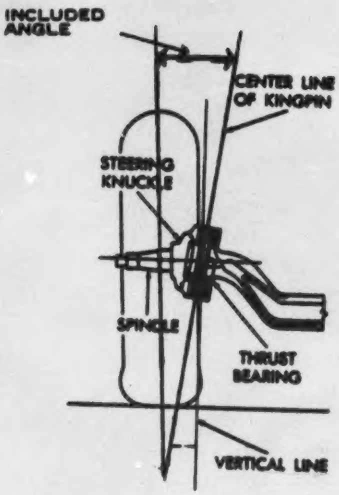
c. The amount of camber must be carefully considered when designing a vehicle as it has some bad effects, and we don't want anymore than what is necessary. Anyone that has ever rolled a tire by hand soon learned that he didn't have to turn the tire in order to turn a corner. All he had to do was to tilt (camber) the tire to one side and it rolled around the corner like a cone. This is not a desirable effect for the wheels of a vehicle. The cone effect of positive camber tries to pivot the wheels out on a vehicle. This is shown in the accompanying illustration. If the wheel is to roll straight ahead it must follow path A, but because of the cone effect it will try to follow path B.

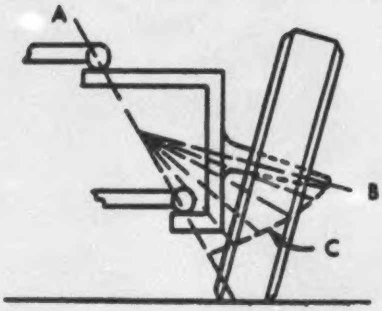




13. KINGPIN INCLINATION. In addition to the caster tilt, the kingpin is also tilted inward at the top. This inward tilt is called kingpin inclination. It is determined by viewing the kingpin or pivot points from the front. Kingpin inclination is another alinement factor that is measured in degrees. It can be shown by drawing two lines that cross to form an angle. One line must pass through the center of the pivot points or kingpin; the other line must be straight up and down.

a. Notice that the kingpin is tilted in the opposite direction from the cambered wheel. Using kingpin inclination will reduce the amount of camber needed to place the point of tire contact with the ground under the steering knuckle pivot. If the front wheels are alined properly, lines that are drawn through the center of the cambered wheel and the kingpin should hit the ground close to where the tire contacts the ground. The combined angles of the kingpin inclination and the wheel cam~~ber is~~ known as the included angle.

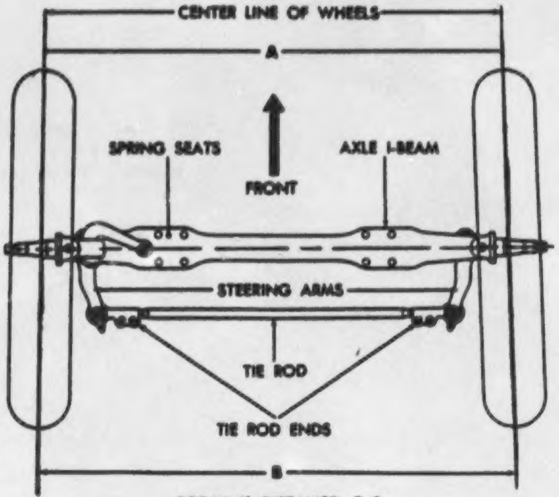




b. Kingpin inclination will also cause an automatic steering effect. The reason for this is shown in the accompanying figure. When the wheel spindle is pointed toward point B, the wheel is in the straight-ahead position. As it pivots for a turn the spindle drops down. Of course, the wheel cannot actually drop downward, because it is already resting on the ground. So the spindle and vehicle are lifted. The weight of the vehicle tries to return the wheel to the straight-ahead position.

14. TOE-IN. Ideally, the front wheels should roll perfectly straight down the road. In fact, if they are not alined so that they do, the tires scuff (slip sideways), wearing the tread rapidly. As the vehicle moves ahead, the wheels resist movement and hold back on the spindles. This force, plus that of the cone effect of camber wheels, causes the wheels to try to pivot outward. That is, the left wheel tries to pivot to the left and the right wheel to the right. The wheels are able to pivot out to some extent because the steering knuckles and tie rod ends must have a slight amount of clearance to permit easy steering. To offset this, the wheels are alined with a slight amount of toe-in.

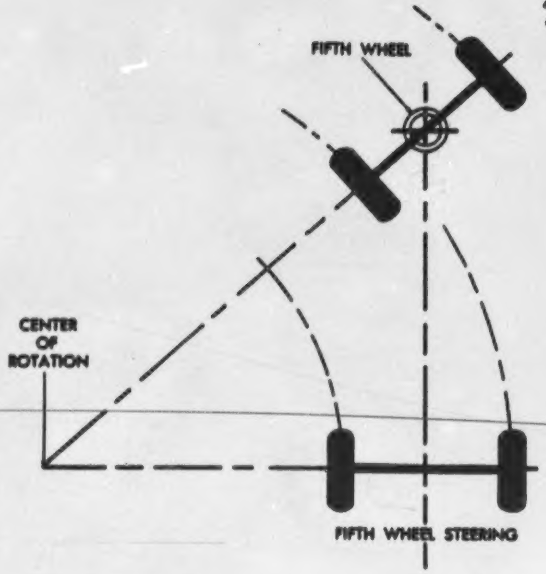
a. Wheels that are toed-in are closer together at the front than at the rear. Toe-in is measured in inches. The amount is found by measuring the distance between the front wheels, first at the front outer edges of the tires and then at their rear outer edges. The amount of toe-in is the difference in the two measurements, which is usually about 1/32 inch to 1/8 inch. If the wheels are closer together in the rear than in the front, they are said to be toed-out. The amount of toe-in can be adjusted by shortening or lengthening the adjustable tie rod.

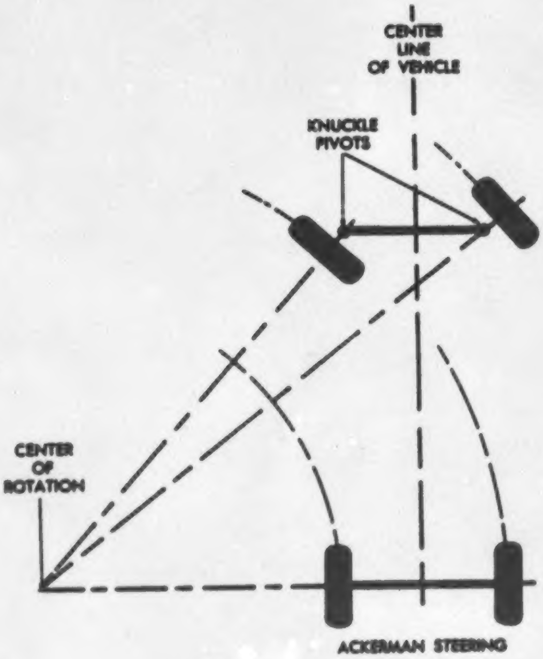


TOE-IN IS DISTANCE B-A
MEASURED IN FRACTIONS OF AN INCH

b. Ideally, the toe-in, as measured with the vehicle stationary, should exactly equal the amount the wheels pivot outward with the vehicle running at its cruising speed. This way, the wheels roll perfectly straight ahead at cruising speed with no side slippage of the tires.

15. TOE-OUT. Side slippage of the tires must also be considered when turning a corner to insure positive steering control and to prevent excessive tire wear. Each wheel must be at a 90-degree angle to the center of rotation if it is to roll easily and not scuff the tread of the tire. This presents no problem for fifth wheel steering. Pivoting the axle assembly moves the front wheel at the outer edge of the turning radius ahead of the inner wheel, and the 90-degree angle is obtained. One straight line can be extended from the center of rotation and passed through the center of both front wheels. With Ackerman steering, however, the wheels must toe-out on a turn. Let's figure out why.



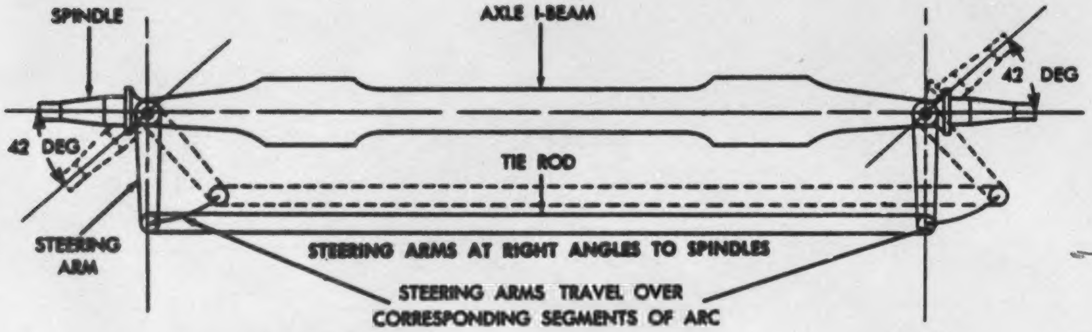


a. When turning a corner with Ackerman steering, one straight line cannot be extended from the center of rotation through the center of both front wheels. Instead, two lines must be extended at different angles in order to pass through the center of the wheels. In order for both wheels to be at a 90-degree angle to the center of rotation, the inner wheel must pivot more than the outer wheel. The exact difference in the amount that the wheels should pivot is the value of the angle formed by the lines extended from the center of rotation through the center of the front wheels. For instance, if the lines form a 3-degree angle, the inner wheel must pivot 3 degrees more than the outer wheel.

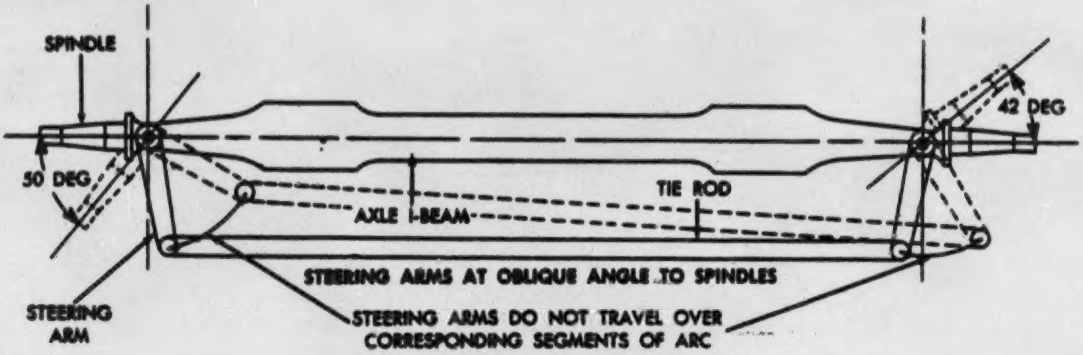
b. From another viewpoint, we can compare the size of the circles that the front wheels travel and see the need for toe-out. The outside wheel is traveling in a larger circle than the inside wheel. In order to travel in a smaller circle, the inner wheel must therefore pivot more than the outer wheel. The sharper the turn, the greater the amount of toe-out needed.

c. The fact that the wheels should be toed-in in the straight-ahead position and then toed-out on turns presents an interesting design problem. The problem is made even harder by the fact that when the vehicle is turned to the left, the left wheel should pivot more; but if turned to the right, the right wheel should pivot more. Let's take a close look at the steering linkage to see how this is done.

(1) First, let's suppose that the steering arms are set at right angles (90°) to the wheel spindles. With this arrangement, toe-out on turns cannot be obtained because both steering arms pivot the same number of degrees when the tie rod is moved a given distance lengthwise to the axle. For example, if the left steering arm and spindle pivot 42 degrees the tie rod moves the right steering arm the same distance, pivoting it 42 degrees. Both steering arms move the same distance lengthwise to the axle and pivot on identical segments of an arc.


SPINDLE
AXLE I-BEAM
42 DEG
42 DEG
TIE ROD
STEERING ARM
STEERING ARMS AT RIGHT ANGLES TO SPINDLES
STEERING ARMS TRAVEL OVER CORRESPONDING SEGMENTS OF ARC

(2) In the vehicle, the steering arms are not at right (90°) angles to the spindle. If the tie rod is behind the axle, the steering arms point inward when the wheels are in the straight-ahead position. With this arrangement, the wheels will toe-out on turns because the steering arms do not pivot the same amount when they move the same amount lengthwise to the axle. Notice that if the left spindle pivots 50 degrees to the left, the right spindle pivots 42 degrees. However, both spindles move the same distance lengthwise to the axle. This is because the steering arms are pivoted on different segments of an arc.


SPINDLE
42 DEG
50 DEG
TIE ROD
AXLE I-BEAM
STEERING ARMS AT OBLIQUE ANGLE TO SPINDLES
STEERING ARM
STEERING ARMS DO NOT TRAVEL OVER CORRESPONDING SEGMENTS OF ARC

(3) Toe-out is generally spoken of as the number of degrees over 20 that the inner wheel is turned when the outer wheel is turned 20 degrees. For instance, if the right wheel is turned 20 degrees and the left wheel 23 degrees on a left turn, the toe-out is 3 degrees.

SECTION III. CONCLUSION

16. SUMMARY.

a. The steering system is one of the most important controls the driver of a vehicle has. Towed vehicles are generally steered by a fifth wheel method, while trucks and passenger cars use Ackerman steering. Steering linkage links the pivoting action of the pitman arm shaft to the front wheels. The main job of the steering gear is to provide a mechanical advantage for easy steering. When it is not practical for the steering gear to provide enough mechanical advantage, some form of power steering is used.

b. To have sure steering, smooth operation, and reasonable tire wear, the wheels must be aimed, or alined, to a definite plan. Alinement angles or alinement factors that are considered in wheel alinement are caster, camber, kingpin inclination, toe-in, and toe-out. The nature and the value of each alinement factor depend to a large extent on the design of the vehicle, so will vary between different vehicles.

17. PRACTICE TASKS. The appendix of this lesson contains a list of tasks associated with wheeled vehicle steering systems. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist who is qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

21. What type of steering system is used on modern cars and trucks?

    a. Ackerman
    b. Radial
    c. Fifth wheel

22. The front wheels of a vehicle revolve on their

    a. pivots.
    b. spindles.
    c. steering knuckles.

23. What connects the front wheels together?

    a. Drag link
    b. Steering arm
    c. Tie rod

24. What is reduced if a worm-and-roller type steering gear is used instead of a worm and sector?

    a. Thrust
    b. Backlash
    c. Friction

25. The threads on the worm of a worm and ball nut steering gear are rounded in order to

    a. increase thread strength.
    b. act as a bearing race.
    c. eliminate road shock.

26. Which type of steering gear uses a tapered stud?

    a. Worm and roller
    b. Worm and ball nut
    c. Cam and lever

27. In the Ross HP 70 power steering unit, what causes the control valve to move?

    a. Hydraulic pressure
    b. Endwise movement of the cam
    c. Rotation of the lever stud

28. In the Ross power steering unit, the relief valve is located in the high-pressure line between the discharge side of the pump and the

    a. reservoir outlet.
    b. control valve.
    c. hydraulic cylinder.

29. What direction must the kingpin be tilted to have positive caster?

    a. Outward
    b. Forward
    c. Backward

30. Positive camber places most of the load on the

    a. inner wheel bearing.
    b. outer wheel bearing.
    c. steering arm.

31. Placing the point of contact between the tire and the road directly under the steering knuckle pivot will reduce the amount of

    a. toe-out needed on turns.
    b. road shock transmitted to the steering linkage.
    c. toe-in required to offset the cone effect of camber.

32. What is controlled by the angle formed by the steering arm and wheel spindles?

    a. Toe-in
    b. Toe-out on turns
    c. Kingpin inclination

33. What changes the rotary motion of the steering gear to linear (straight line) motion?

    a. Drag link
    b. Pitman arm
    c. Tie rod

34. When all the steering linkage is behind the axle, lengthening the tie rod will

a. increase toe-in.
b. reduce toe-in.
c. increase toe-out on turns.

35. What two steering angles are combined to make the included angle?

a. Caster and camber
b. Camber and kingpin inclination
c. Kingpin inclination and toe-in

36. Clearance between the worm and sector teeth is controlled by the

a. thrust bearings.
b. lash adjusting screw.
c. recirculating balls.

37. In the Ross power steering unit, the hydraulic assist is applied directly to the

a. cam.
b. pitman arm.
c. lever.

38. What alinement factor is obtained by tilting the steering knuckle pivots inward at the top as viewed from the front of the vehicle?

a. Camber
b. Kingpin inclination
c. Caster

39. The automatic steering effect is also known as

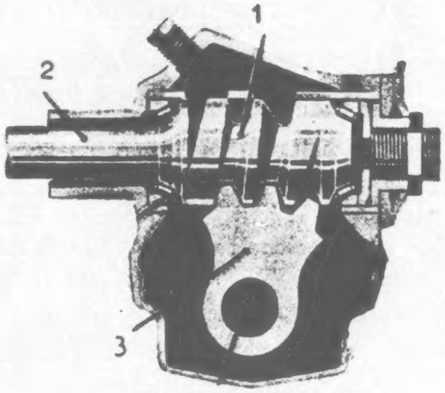
a. hydraulic steering.
b. self-righting action.
c. toe-out on turns.

40. What alinement factor causes the front tires to try to roll like a cone?

a. Caster
b. Camber
c. Toe-in

41. What steering gear part shown in the illustration works much like a nut?

a. 3
b. 2
c. 1

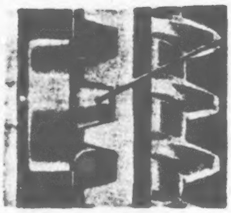


42. In what direction must the tops of the kingpins be tilted to cause an automatic steering effect that tends to steer the vehicle into a crosswind?

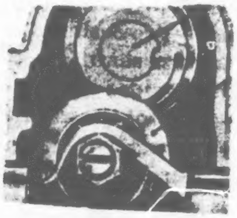
a. Forward
b. Backward
c. Inward

43. What illustration shows the worm and roller steering gear?

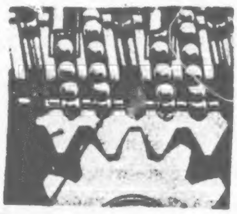
a.



b.



c.



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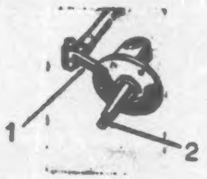
44. Which statement concerning steering gears is true?

- a. The pitman arm shaft and the worm shaft rotate at the same speed
- b. The mechanical advantage is greater when the front wheels are pivoted all the way to the right or left than when straight ahead
- c. Lash between the worm and the sector is not as great when the vehicle is going straight ahead as it is when turning a corner

45. Which alinement factor will be affected if the angle formed by items 1 and 2 in the illustration are changed?

- a. Caster
- b. Camber
- c. Toe-out



APPENDIX

PRACTICE TASK LIST

Practice Objective . . . . After practicing the following tasks you will be able to:

1. Locate the components of a wheeled vehicle steering system.
2. Inspect the steering system of a 1/4-ton or a 2-1/2-ton truck for general appearance and completeness.
3. Inspect the steering system of a 5-ton truck for general appearance and completeness.

Practice Tasks.

1. Inspect the steering gear assembly and all of the steering linkage used on several different types of vehicles. If available in your unit, check especially the steering system found on the 1/4-ton truck M151, which has an independent suspension system; and the 5-ton truck M141 or M54A2-series, which has a power steering unit. Use the appropriate TM's and identify the following components found on the two vehicles specified:

a. Steering gear assembly.

b. Pitman arm shaft.

c. Drag link.

d. Tie rod(s).

e. Idler or relay arm rod.

f. Idler arm.

g. Steering knuckles, kingpins, or ball joints.

h. Spindles.

i. Power steering pump, reservoir, power cylinder, control valve, and hydraulic lines.

2. Have an assistant turn the steering wheel back and forth while you check the steering gear and linkage for evidence of excessive looseness. Examine the following parts very closely:

a. Steering gear-to-frame mounting bolts.

b. Steering column-to-instrument panel clamp.

c. Pitman arm shaft nut.

d. Idler arm mounting bolts and bushing.

e. Steering arm mounting bolts.

f. Lubricant level in the steering gear.

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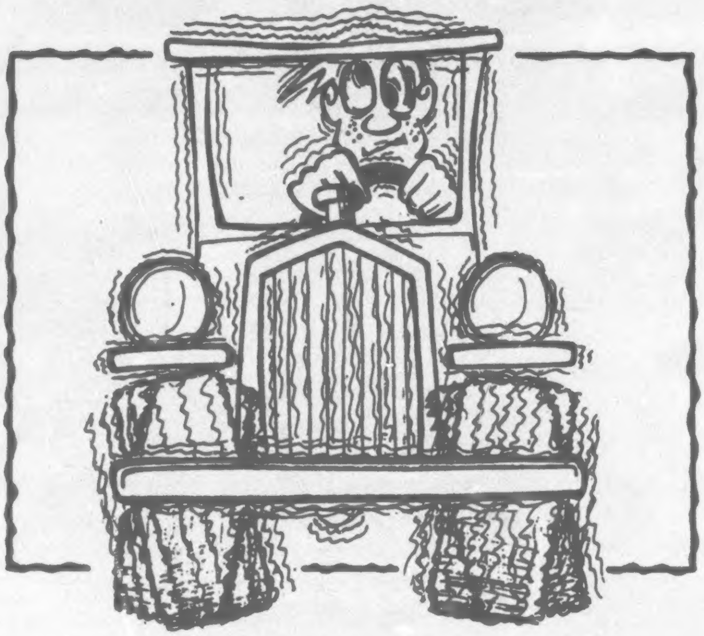
CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B207



LESSON 3

MAINTENANCE OF MECHANICAL STEERING GEAR ASSEMBLIES

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B207-3 . . Wheeled Vehicle Steering Systems

Lesson 3 . . . . Maintenance of Mechanical Steering Gear Assemblies

Credit Hours . . . . Two

Lesson Objective . . . . After studying this lesson you will be able to:

1. Describe the common steering problems of mechanical steering systems.
2. State the procedures for inspecting the steering gear of a 1/4-ton truck M151.
3. Describe the procedures for adjusting the steering gear of a 1/4-ton truck M151.
4. Describe the procedures for replacing the steering gear of a 1/4-ton truck M151.
5. Explain how a steering wheel is removed and replaced on a 1/4-ton truck M151.

6. State the procedures for inspecting the steering gear of a 2-1/2-ton truck.

7. Describe the procedures for adjusting the steering gear of a 2-1/2-ton truck.

8. Describe the procedures for replacing the steering gear of a 2-1/2-ton truck.

Text	Attached Memorandum
Materials Required	Answer sheet and response list
Suggestions	Refer to the illustrations while reading the text

FOREWORD

Modern wheeled vehicles are designed so that the operator uses very little effort to operate the vehicle. Because there has been great improvement in steering mechanisms, heavy vehicles can now be braked and steered with ease.

Without proper maintenance, however, these steering mechanisms can change from the easy operating controls they should be to useless, dangerous controls. The steering system must be kept in proper condition for the sake of safety.

Maintenance of mechanical steering gears is spread over various categories of maintenance. Although all of this maintenance is important, organizational maintenance is expected to find the troubles first. If troubles are fixed at this level, it can prevent larger repairs at a later time.

During a previous lesson you learned how mechanical steering gears were constructed. The purpose of this lesson is to cover some of the maintenance procedures for mechanical steering gears.

ATTACHED MEMORANDUM

SECTION I. TROUBLESHOOTING STEERING SYSTEMS

1. INTRODUCTION. The steering gear is one of the most used wheeled vehicle controls. Should the steering operate improperly, the operator loses little time in reporting the problem. With a faulty steering gear, he knows that he is gambling with his life as well as with the lives of his passengers.

a. As a wheeled vehicle mechanic, you are responsible for some of the maintenance on the steering system. This maintenance includes troubleshooting and minor repairs on the steering gears of wheeled vehicles.

b. Another maintenance function for which you are responsible is inspecting the overall condition of steering gears. This is probably the most important maintenance function of all. Let's go over some of the maintenance that can be performed on steering gears. We will start with some of the problems you will find when troubleshooting.

2. COMMON STEERING PROBLEMS. The steering systems, like other wheeled vehicle mechanical parts, can develop various problems. Some of these problems are caused by "unwanted factors" that affect the steering. Examples of these factors are wandering, shimmy, and hard steering. As a wheeled vehicle mechanic, you must know how to locate the causes of these problems. We call this troubleshooting.

a. These unwanted steering factors in wheeled vehicles are often referred to by such terms as indicated above - wandering and shimmy. Not all of the steering problems are caused by the steering gear. However, you will need to know these terms either in this lesson or later lessons in this subcourse.

b. Let's go over these steering terms and at the same time learn their symptoms and causes. As you study the remainder of the lessons you will then know what the terms mean. Once you have completed this lesson you should understand how to troubleshoot the wheeled vehicle steering gears. Let's start with hard steering.

(1) Hard steering. This term means just what it indicates - the steering wheel is hard to turn. Hard steering can cause the operator to have trouble turning the wheel. It can also cause the operator to have to fight the wheel to keep the vehicle traveling straight down the road. It can be caused by lack of lubrication, bent parts, and improper adjustments.

(2) Loose steering. This term means just what it indicates. It is caused by steering parts that are worn, broken, or out of adjustment. The driver must turn the wheel excessively to steer the vehicle.

(3) Wandering. This means the vehicle wanders over the road. A vehicle should, if properly loaded, travel straight down a level road with little or no guidance by the operator. If the vehicle wanders, the operator must continuously turn (fight) the steering wheel to keep the vehicle traveling straight.

(4) Shimmy. Shimmy means the front wheels move "in and out" or vibrate at certain speeds. Shimmy is definitely noticeable in the steering wheel. If the shimmy is bad enough, it can be very dangerous because its force can break some of the steering parts. Shimmy can be caused by wheels and tires that are out of balance, bent wheels, as well as other causes you will learn in later lessons. Shimmy will show up much worse if the steering parts are worn or out of adjustment; however, this is not the actual cause of shimmy.

(5) Wheel tramp. The term "wheel tramp" means the wheels are "bouncing up and down." This also is noticeable in the steering wheel, but as a vibration, whereas shimmy tries to turn the steering wheel back and forth. Wheel tramp, like shimmy, is also caused by wheels and tires that are out of balance. However, the out-of-balance portion is equal across the wheel or tire. This causes the wheel to move straight up and down rather than sideways as found in shimmy. Wheel tramp, like shimmy, will show up much worse on a vehicle if some of the parts are loose, worn, or improperly adjusted.

(6) Vehicle pulls to one side. This can have many causes; however, the mechanical steering gear can hardly be blamed for this malfunction. The causes range from low tire pressure on one side of the vehicle to a bent frame. This malfunction will be covered in a later lesson in this subcourse.

(7) Erratic steering. This means the steering does not continue to act the same all the time. For example, the vehicle could pull to the right for a while and then start pulling to the left. If the vehicle pulls to one side when the brakes are applied, the vehicle is also considered to have erratic steering. Another major cause of erratic steering is a load that moves about or too much load on one portion of the body, especially the rear.

(8) Rough steering. This term means the steering wheel does not turn smoothly. This could be caused by damaged components in the steering gear or steering linkage. Damaged steering gear components could be a pitted worm (helical cam, 2-1/2-ton) or roller or lever pins. Loose or pitted knuckle support bearings could also cause the problem. A quick way to isolate the trouble is to first disconnect the steering gear from the rest of the steering mechanism. Then turn the steering wheel. If the roughness is still there, the trouble is in the steering gear.

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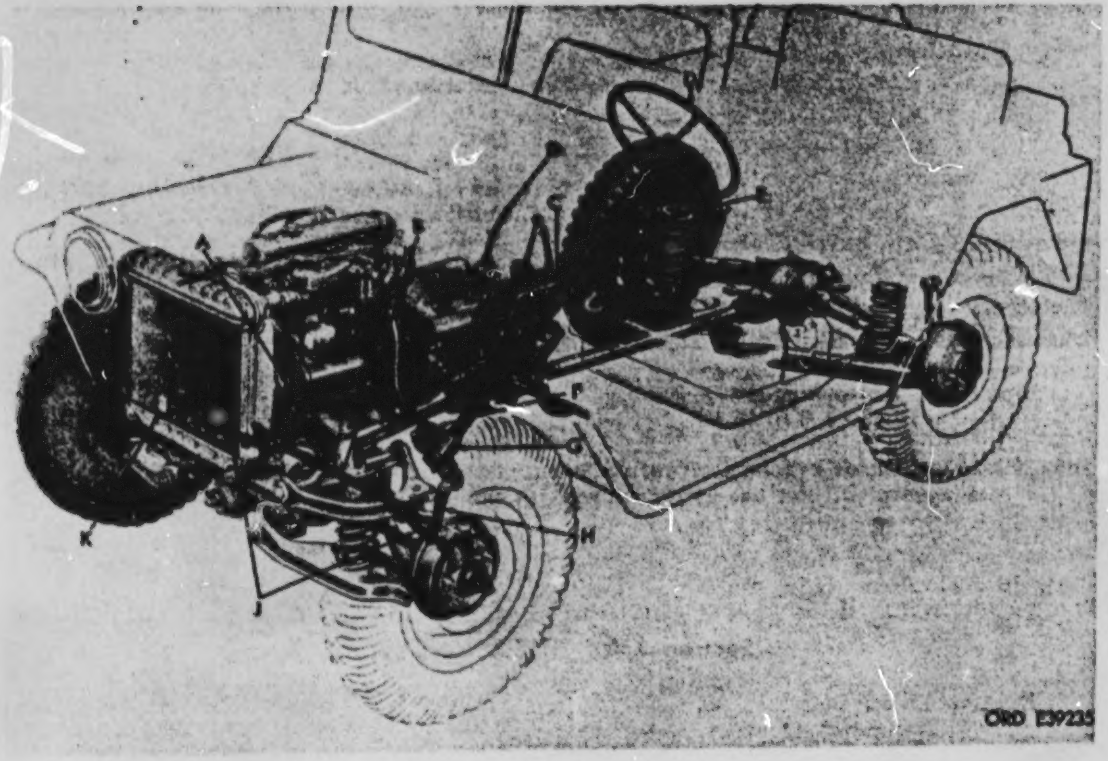
(9) Drive. This is another steering malfunction. It means the vehicle, when turned in either direction, tries to turn more rapidly than the operator intends. This can be caused by bent, loose, or broken parts. This is especially true if the steering gear assembly is loose on the frame.

c. Now that we have covered most of the common steering malfunction terms, we can see that some can be caused by others. For example, "wandering" and "drive" can both be caused by loose steering parts. We should also notice that some of the malfunctions have the same symptoms. For example, "hard steering" and "wandering" have the same symptom - the operator must continue to "fight" the steering wheel. The good trouble-shooter always makes a complete inspection of the components before he removes or replaces any parts. Usually, by using his knowledge of the construction and operation of the parts, looking at the symptoms, and making an inspection, he can easily locate the trouble. Let's see how you should inspect the steering gears. We will start with the 1/4-ton truck.

SECTION II. 1/4-TON TRUCK M151 STEERING GEAR MAINTENANCE

3. STEERING GEAR INSPECTION. Before we cover the inspection of the steering gear, let's see what type of steering gear is used in the 1/4-ton truck M151. This vehicle's steering gear assembly is the worm-and-roller type. The roller has two teeth that mesh with the worm, so it is usually called a two- or double-tooth roller. The steering gear is mounted on the body frame left side rail. The steering column is supported by a bracket attached to the instrument panel.



Steering System

Legend:

Key	Item
A	Idler arm mounting bracket
B	Pitman arm to idler arm rod
C	Steering column
D	Steering wheel
E	Steering column to dash panel bracket
F	Adjusting screw
G	Steering gear assembly
H	Steering pitman arm
J	Spindle arm tie rod assy
K	Spindle arm

a. Let's see just what components there are in the steering assembly and how they fit together.

Note. - Go to page 31 of this lesson and fold out the illustration of the steering gear so that you can refer to it during the 1/4-ton truck part of the lesson.

(1) The steering gear worm gear is pressed on the steering shaft (items X and H in the illustration). Two tapered roller bearings (items W and Y) support and prevent endwise movement (thrust) of the worm and shaft.

(2) A steel trunnion pin attaches the double roller to the sector shaft (item BB). The sector shaft is mounted in bushing type bearings pressed into the steering gear housing (item L). Four capscrews attach the sector shaft cover (item A) to the steering gear housing. An adjustment screw engaged in the sector shaft is threaded into the cover and controls sector shaft end play as well as the lash (movement) between the teeth of the worm and the roller. Adjustment of the worm thrust bearing (items W and Y) is made by installing or removing gaskets (item V) of various thicknesses between the gear housing and the housing cap (item S).

(3) A ball type bearing pressed into the steering column tube supports the shaft at the steering wheel end (item DD).

(4) The pitman arm (item Q) and the steering wheel (item E) have fluted serrations (splines), with one serration being double width. The double width splines match blind splines on the sector shaft and the steering shaft to insure correct installation.

b. Now that we have an idea of what the steering gear and the parts in it look like, let's see how to go about inspecting it.

(1) Examine the steering column and steering wheel to see if they are bent, cracked, or damaged in any way.

(2) Look for leaking seals and gaskets. There are three oil seals in this steering gear. They are items K, M, and T in the foldout. There are also two gaskets that can leak. They are items V and AA in the foldout. Even if the seals and gaskets are not leaking, the lube level in the steering gear housing should be checked.

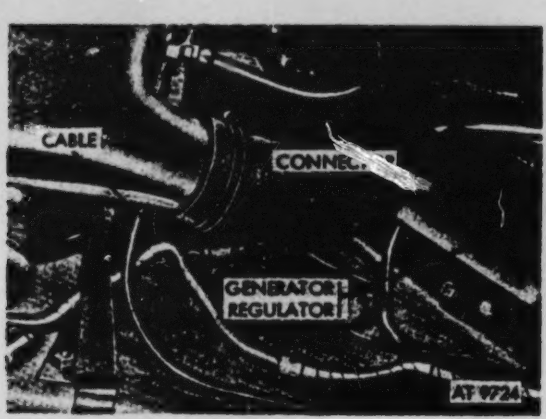
(3) Check the mounting brackets and bolts for secure mounting. To do this, you have to do more than look; use a wrench to see if the bolts are tight.

(4) Check for too much free play (slack) in the steering system. You should remember from the previous lesson that steering gears are designed to have very little free play when the wheels are straight ahead. This means that when the steering wheel is in the center of its travel, there should be no noticeable free play. This center point is called the high point or midposition. When the steering gear is not on the high point, some free play is normal.

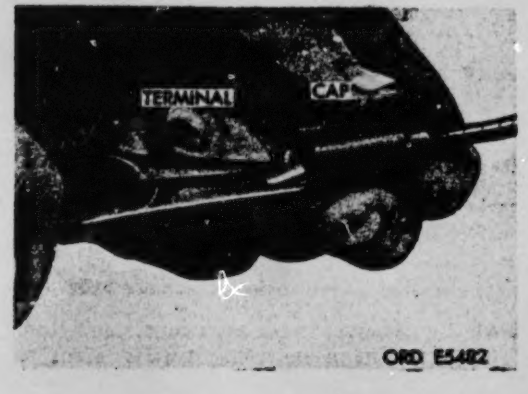
(5) Next, road test the vehicle and check for binding, wander, or shimmy while the vehicle is moving forward.

c. If any of the above malfunctions show up, they may be caused by the steering gear or by some of the linkage. Let's suppose the trouble is binding. It will now be necessary to take the load off of the steering gear by disconnecting the steering linkage from the steering. If the binding is still present when the steering wheel is turned after the linkage is disconnected, the trouble is in the steering gear. This is as far as an organizational mechanic can go, because adjusting or replacing the steering gear on this vehicle is a job for field maintenance.

4. STEERING WHEEL REPLACEMENT. The 1/4-ton truck M151 steering wheel can be removed and replaced by organizational maintenance personnel. Let's see how it is done.

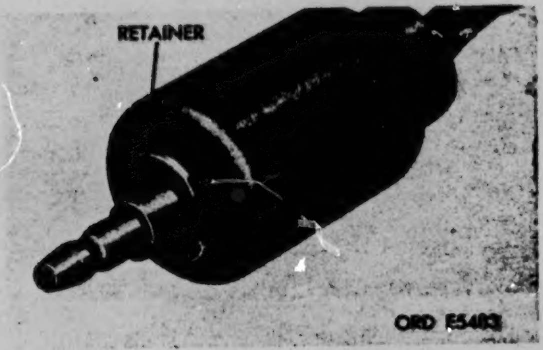


a. The first step, for safety purposes and to prevent accidental horn blowing, is to disconnect the negative (ground) battery cable (left battery). Then separate the horn cable electrical connector below the generator regulator.



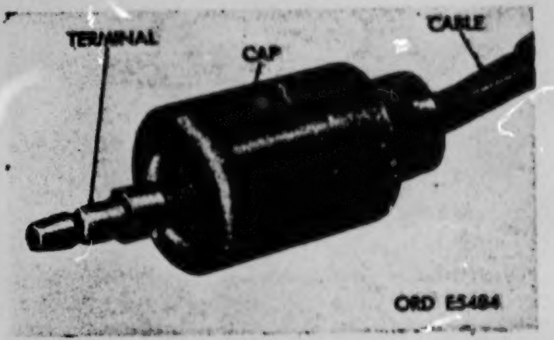
b. Once this is done, pull the terminal out of the rubber cap of the connector. You can use pliers to grip the terminal to pull it out.

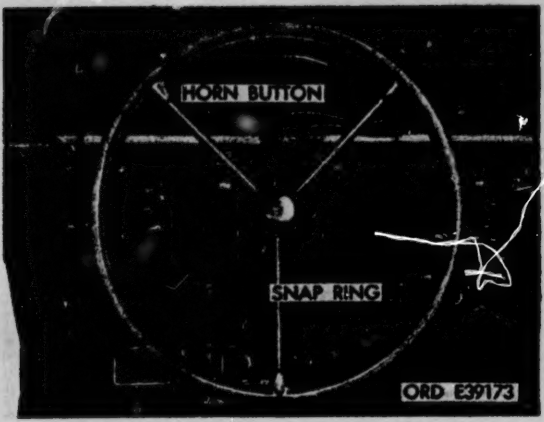
93


RETAINER
ORD E5483

c. Once you have pulled the terminal out far enough to see the "C" washer type retainer, pull the retainer off of the cable.

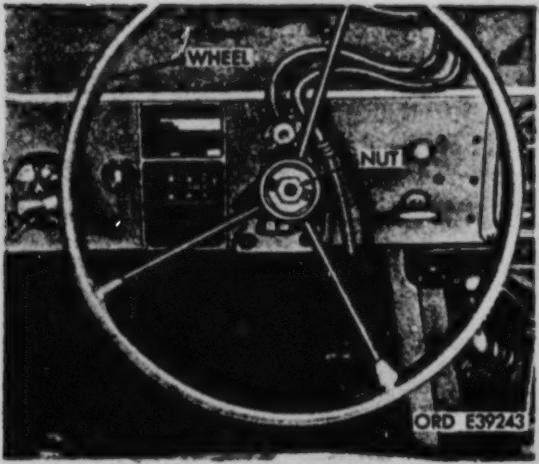
d. Now you can slide the rubber cap off the cable.

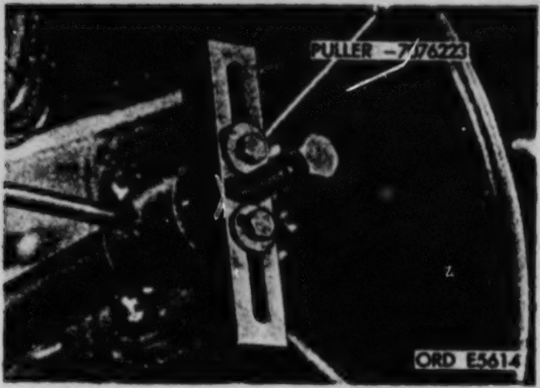

TERMINAL
CAP
CABLE
ORD E5484


HORN BUTTON
SNAP RING
ORD E39173

e. Next, you should remove the horn switch (horn button). It is held in place with a snapring. Hold one hand over the snapring to prevent it from hitting you in the face and pry it out with a suitable tool. Then remove the horn switch and wire from the steering by lifting the assembly up and pulling the wire out of the shaft.

f. Now you can see the nut that holds the steering wheel on the shaft. Loosen the nut until it is flush with the end of the shaft. This will help prevent burring of the shaft by the puller.





g. Install the puller with the adapter between the puller screw and the steering shaft and nut. If no adapter is available, use a thick washer between the screw and the nut and shaft. This will protect the shaft from the puller screw.

h. Then turn the puller screw clockwise until the steering wheel "jumps up" against the nut. Remove the puller and then remove the nut. You should now be able to pull the steering wheel off by hand.

i. Once the steering wheel is removed, inspect the condition of the splines on the steering shaft. Check the condition of the threads on the end of the shaft and in the nut. If the threads are stripped or the splines are burred, nicked, or damaged in any way, notify support maintenance. If the shaft and nut are serviceable, you are ready to install the new steering wheel. The steering wheel is installed in the reverse order of removal. Let's briefly go over the steps.

j. Aline the steering wheel so that the double width splines line up. It may be necessary to move the wheel a little either way to aline the splines.

k. Slide the steering wheel on the steering shaft and install the retaining nut. Tighten the nut to 25 to 35 lb-ft of torque. Then stake the nut to the shaft. This can be done by placing a center punch close to the threads of the nut and then striking the center punch with a hammer. This pushes a small amount of both threads inward and tends to lock the two threads together.

l. Next, guide the horn cable (wire) into the steering shaft and install the horn button and snapring.

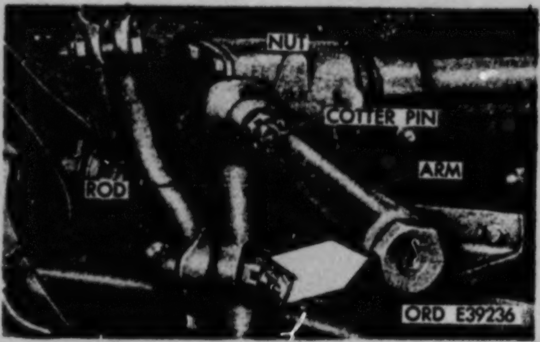
m. Slide the rubber cap onto the horn cable and replace the "C" washer type retainer. If the rubber cap is hard to slide onto the cable, lubricate the cable with some liquid hand soap or very soapy water. Once the "C" washer type retainer is in place, slide the rubber cap over it until the rubber cap bottoms on the retainer.

n. Next, connect the horn cable where you disconnected it at the generator regulator. Then connect the battery cable and tighten it securely. This completes the replacement of the steering wheel.

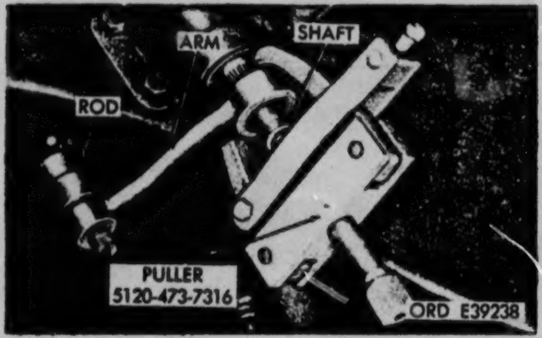
5. STEERING GEAR ADJUSTMENT. It has already been mentioned in this lesson that it is not the job of the mechanic at organizational level to remove and replace the steering gear of an M151. Neither is the steering gear adjustment made at this maintenance level. But if you are not now, you may sometimes be working at a maintenance level higher than organizational. For this reason we are going to cover the removal, replacement, and adjustment of steering gears on the M151.

a. When adjusting the steering gear of a 1/4-ton truck M151, you should first make sure it is not mounted in a bind on the truck. This is done in the following manner:

(1) Remove the nut and lockwasher securing the pitman arm to the sector shaft.



(2) Using a puller, remove the pitman arm from the sector shaft. Care must be taken when using a puller of this type. First, make sure the puller hooks are clamped securely against the pitman arm. This is done by tightening the setscrew on the side. Next, make sure the main puller screw does not "mushroom" or spread the end of the sector shaft. Position the end of the screw in the recess (hole) in the end of the pitman shaft.

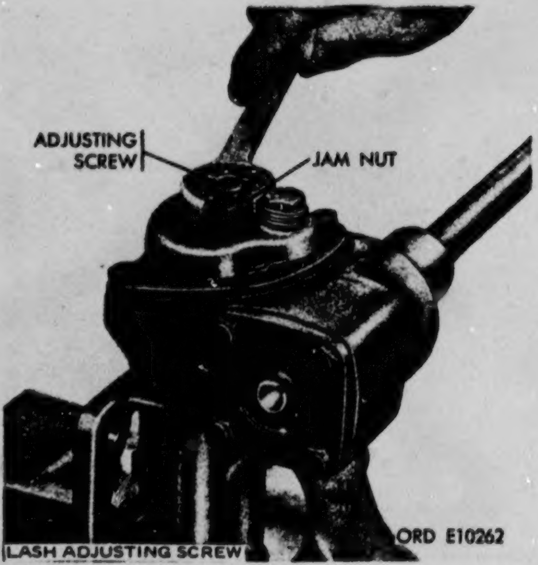


(3) Once the pitman arm is removed, loosen the bolts securing the steering gear to the frame side rail. Loosen the bolts attaching the steering column to the instrument panel.

(4) Now that the steering gear is loose, retighten the bolts in the following manner: Torque the bolts attaching the steering column to the instrument panel to 12 - 15 lb-ft. Torque the bolts securing the steering gear to the side rail to 25 - 30 lb-ft. The steering gear should now be mounted with no bind.

b. The steering worm bearing adjustment should be checked in the following manner:

(1) Back the roller away from the worm by loosening the lash adjusting screw 1/2 turn. Turn the steering wheel two complete turns from the center of its travel in either direction.



(2) Hook a spring scale to the steering wheel at the point where one of the spokes joins the rim. Turn the wheel at least one turn in the opposite direction by pulling on the scale. Note the amount of pull needed to keep the wheel moving. The scale reading should be between 5.0 and 15.4 ounces. A reading that is too high indicates the worm thrust bearings are too tight and a gasket or gaskets should be added. A reading that is too low indicates that the bearings are too loose and gaskets must be removed. These gaskets are installed between the steering gear housing and the steering gear cap (item V of the foldout in the back of the lesson). The gaskets come in varying thicknesses.

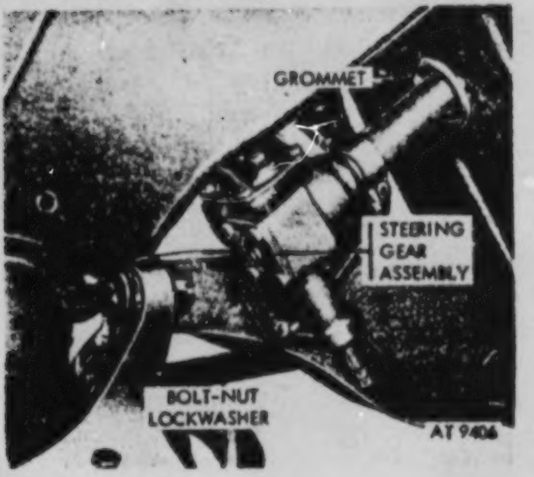
(3) Remove or add one gasket at a time. Check the worm bearing adjustment after each change in the gasket pack. The steering gear housing cap must be installed on the steering gear housing each time the bearing adjustment is checked. The housing cap bolts must be torqued to 10 - 15 lb-ft.

c. The worm-and-roller mesh (lash) adjustment is controlled by the lash adjustment screw mounted in the sector shaft cover. To make this adjustment, turn the steering wheel from lock to lock (extreme right to extreme left). Count the number of turns. Turn the steering wheel back halfway. This is the steering gear high spot or midposition. Turn the adjusting screw in until there is a drag on the steering wheel. Tighten the jam nut finger tight. Hook the spring scale to the steering wheel as described above. Turn the wheel through the high spot with the scale. The scale reading should be between 1.6 and 2.2 pounds. If the reading is too high, turn the adjusting screw counterclockwise and check the tension again. If the reading is too low, turn the adjusting screw clockwise and again check the tension. When the correct tension is obtained, lock the jam nut by holding the adjusting screw in place with a screwdriver and tightening the nut with a wrench.

6. STEERING GEAR REPLACEMENT. Now that we know how to adjust the 1/4-ton steering gear, let's go over the procedures that are used to replace the steering gear.

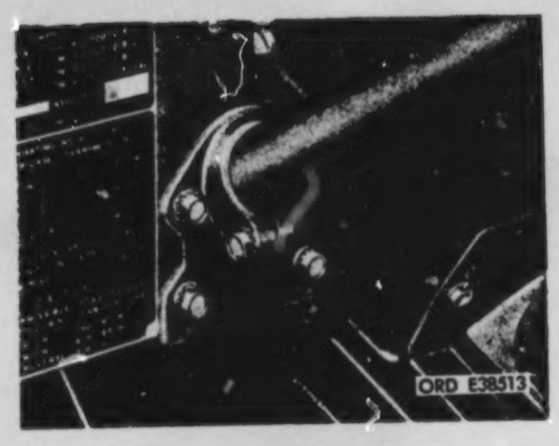
a. To remove the steering gear on a 1/4-ton truck M151, use the following procedures as a guide:

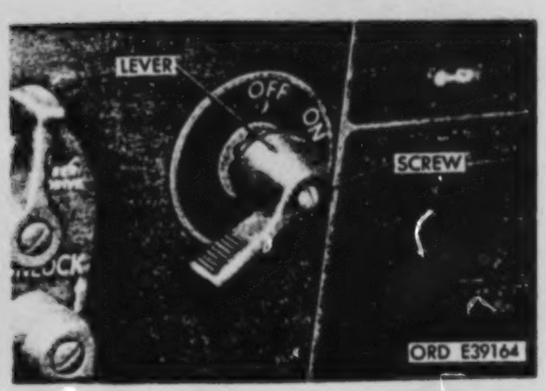
(1) First, disconnect the negative battery cable. Then jack the front of the vehicle up and support it with blocks or a jackstand. Remove the left front wheel and tire. Then remove the pitman arm from the pitman arm shaft. Next, remove the horn wire and the steering wheel.


GROMMET
STEERING GEAR ASSEMBLY
BOLT-NUT LOCKWASHER
AT 9406

(2) Remove the bolts, nuts, and lockwashers securing the steering gear to the frame side rail. Remove the rubber grommet from the toe panel and slide it down the column.

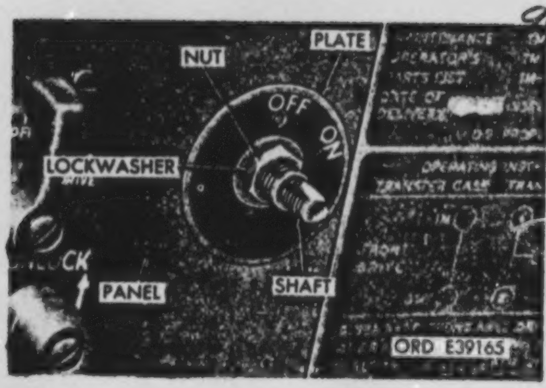
(3) Loosen the steering gear column clamping bolt on the instrument panel bracket. Remove the bolts securing the column bracket to the instrument panel. Remove the bracket.

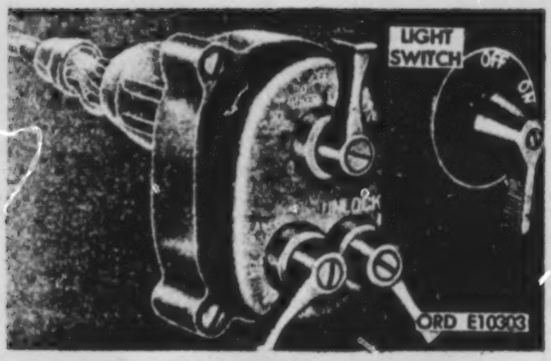



LEVER
OFF
ON
SCREW
LOCK
ORD E39164

(4) Next, remove the two wiring harness clips under the edge of the instrument panel. Then remove the screw from the center of the ignition switch lever and remove the switch lever.

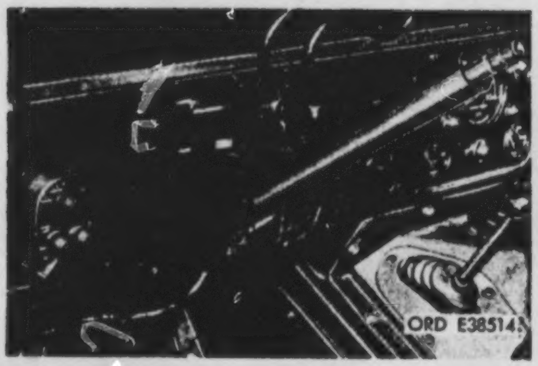
(5) Remove the nut and washer securing the ignition switch and switch nameplate to the dash panel. Push the ignition switch out of the dash panel hole and lower it below the dash panel.


NUT
PLATE
OFF
ON
LOCKWASHER
UNLOCK
PANEL
SHAFT
ORD E39165


LIGHT SWITCH
OFF
ON
UNLOCK
ORD E10303

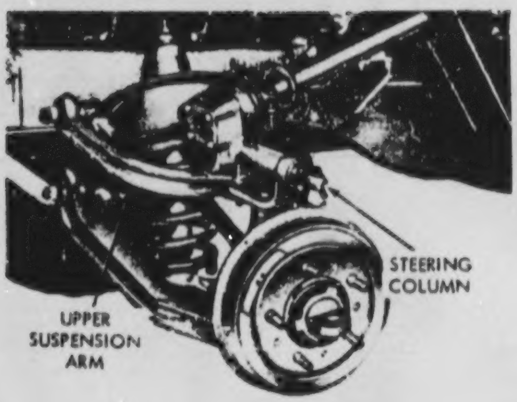
(6) Once this is done, disconnect the front wiring harness at the light switch and the stoplight switch.

(7) Hold the column against the top of the slot in the instrument panel. Then work the wiring harness out of the lower flange of the instrument panel.



100

(8) Make sure that the vehicle is supported on the jackstands in a manner that allows the front suspension system to swing down to the lowest point. Pull the steering column through the hole in the dash panel and at the same time pass the steering gear over the front suspension upper arm.



b. To install the new steering gear on a 1/4-ton truck M151, use the following procedures as a guide:

(1) Push the steering column over the front suspension upper arm through the hole in the dash panel.

(2) Hold the steering column against the top of the slot in the instrument panel. Work the wiring harness back into the lower flange of the instrument panel and connect the harness to the light switch and stoplight switch. Reinstall the ignition switch and replace the two harness clips under the edge of the instrument panel.

(3) Next, replace the column bracket and the bolts securing the column bracket to the instrument panel. Tighten the steering gear column clamping bolt on the instrument panel bracket. Replace the rubber grommet in the toe panel. Replace the lockwashers, nuts, and bolts securing the steering gear to the frame side rail.

(4) Then replace the steering wheel and horn wire. Replace the steering pitman arm. Check the position of the steering wheel. With the front wheels in the straight-ahead position, one spoke of the wheel should be pointing straight downward. If not, the steering linkage must be adjusted. Linkage adjustment is covered in a later lesson.

(5) Next, replace the left front wheel and tire. Remove the blocks or jackstand and lower the vehicle to the ground. Reconnect the negative battery cable.

(6) Fill the steering gear with the proper gear oil (GO), depending on the climatic temperature. Use GO 90 for temperatures that stay above 32° F and GO 75 for temperatures that range between -10° and +50° F.

SECTION III. 2-1/2-TON TRUCK STEERING GEAR MAINTENANCE

7. STEERING GEAR INSPECTION. Now let's take a look at the steering gear used on the 2-1/2-ton truck M35A1 or M35A2. This steering gear is the cam-and-lever type. The gear housing, like the 1/4-ton steering housing, is bolted to the left side frame rail of the truck. The steering gear shaft is enclosed in the tube or jacket which is joined to the gear housing by a flanged cover. The jacket and housing are watertight. To inspect this steering gear, use the following procedures as a guide:

a. First, examine the steering column and steering wheel for bends, cracks, or other signs of damage, and check for secure mounting.

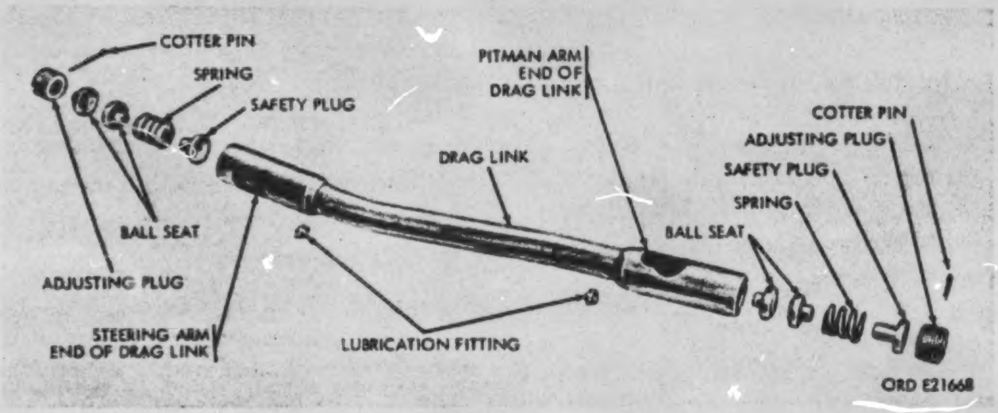
b. Next, look for leaking seals or gaskets. Check the lube level in the steering gear housing. Turn the steering wheel from one extreme to the other and check for excessive slack, binding, rough spots, or noise.

c. Then road test the vehicle. Check for excessive steering free play, binding, wander, shimmy, and for a tendency to pull to one side.

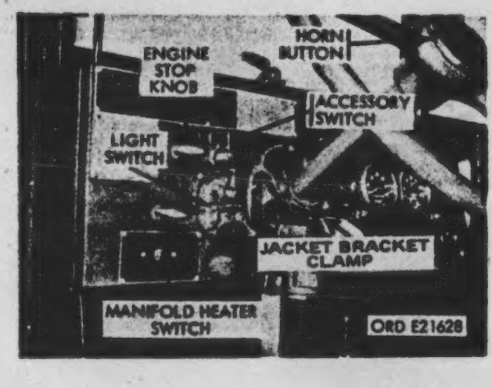
8. STEERING GEAR ADJUSTMENT. The repairman at the organizational maintenance level is allowed to do more to the steering gear on a 2-1/2-ton truck M35A1 or M35A2 than he can on the 1/4-ton M151. Let's take a look at some of the things he can do.

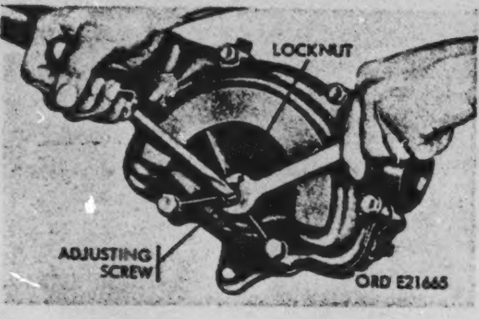
a. Two steering gear adjustments can be made on the 2-1/2-ton truck M35A1 or M35A2. One is the cam bearing end play adjustment and the other is the steering gear backlash adjustment. Let's start with the cam bearing end play adjustment and see how it's done.

(1) First, remove the cotter pin from the pitman arm end of the drag link. Then loosen the adjusting plug as much as possible without removing it. Turn the steering wheel in both directions to loosen the ball seats. Remove the adjusting plug from the pitman arm end of the drag link. Pull the link from the pitman arm. Be careful not to lose any parts from the inside of the link. Tip the link end down and remove the safety plug, ball seat spring, and ball seats. The purpose of disconnecting the drag link is to take the load off of the steering gear so it can be adjusted.


COTTER PIN
SPRING
SAFETY PLUG
BALL SEAT
ADJUSTING PLUG
STEERING ARM END OF DRAG LINK
DRAG LINK
LUBRICATION FITTING
PITMAN ARM END OF DRAG LINK
COTTER PIN
ADJUSTING PLUG
SAFETY PLUG
SPRING
BALL SEAT
ORD E21668

(2) Next, loosen the steering mounting bolts and the jacket bracket clamp on the instrument panel, and then retighten the housing mounting bolts to 60 - 65 lb-ft torque. This assures there is no bind on the steering shaft and bearings.

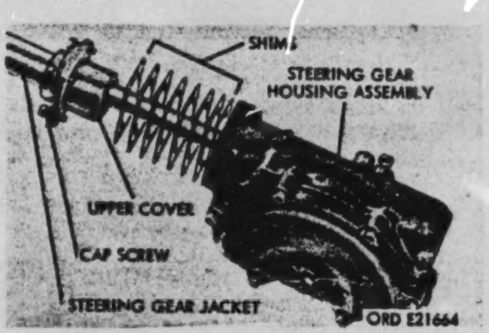

ENGINE STOP KNOB
HORN BUTTON
ACCESSORY SWITCH
LIGHT SWITCH
JACKET BRACKET CLAMP
MANIFOLD HEATER SWITCH
ORD E21628



(3) Next, back the pitman arm shaft lever studs away from the cam (worm) so it won't cause a drag when you are checking the cam bearing adjustment. This can easily be done by first unlocking the locknut and then turning the adjusting screw to the left for at least one complete turn.

b. How do we know when the cam bearings are adjusted right? The cam bearings are in proper adjustment when there is no free play in the bearings. If the worm shaft can be moved either in and out of the housing or sideways in the housing, the bearings are too loose or have too much free play. However, if there is no free play and there is some drag (preload), the bearings are too tight. If the bearings are too tight, shims must be added to decrease the preload. If the bearings are too loose, some of the upper housing shims must be removed.

c. Let's say the bearings are too loose. To remove the shims, disconnect the horn cable near the lower end of the steering gear. Remove the screws holding the steering gear housing upper cover to the gear housing. With the jacket bracket clamp on the instrument panel loosened, pull the upper cover and steering gear jacket from the gear housing. This exposes the adjusting shims. Do not, however, pull the jacket up any farther than necessary to avoid damage to the horn wire. The shims are all either 0.002 inch, 0.003 inch, or 0.001 inch thick. Clip and remove a thin shim. Assemble the jacket and housing and recheck. You may take out too many shims and get the bearings too tight. If so, replace one thin shim at a time until you get the proper adjustment. You may also have to change the thickness of one shim to get the proper adjustment. Don't forget to reconnect the horn cable.



d. To make the steering gear backlash adjustment, first, tighten the jacket bracket clamp on the instrument panel and then turn the steering wheel counterclockwise as far as possible. Next, turn the wheel clockwise as far as possible and count the number of turns. Finally, turn the wheel back 1/2 the total number of turns. The steering gear assembly is now in the high point or midposition. Next, turn the backlash adjusting screw until a slight drag is felt when the steering wheel is turned back and forth through the midposition (high point). Adjustment of this screw is critical. Tightening the screw too much will cause the steering to bind. Not enough tightening will cause the steering to be too loose. After the adjustment, tighten the locknut and recheck the drag. This completes the backlash adjustment between the helical cam and the lever studs.

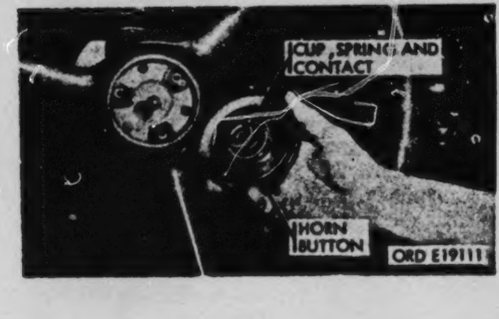
e. With both adjustments completed, we are ready to install the drag link. To install the drag link, place one ball seat in the pitman arm end of the drag link with the cupped surface facing the pitman arm ball opening. Install the drag link over the pitman arm ball. Install the second ball seat in the link with the cupped surface toward the ball. Then install the ball seat spring, safety plug, and adjusting plug in the drag link. Next, screw the adjusting plug in tight and then back the screw out 1/2 turn, or less, until the adjusting plug slot lines up with the cotter key holes in the drag link. Install a new cotter key and you have finished adjusting the steering gear.

9. STEERING WHEEL REPLACEMENT. Basically, the 2-1/2-ton truck steering wheel is removed in the same general manner as the 1/4-ton truck. However, there are some differences, so let's see how it's done.

a. The M35-series 2-1/2-ton truck steering wheel has one important difference from the 1/4-ton truck steering wheel: it can be mounted on the steering shaft in more than one position. This is possible because it does not have any double-width splines. All the splines in the steering wheel and the steering shaft are the same size. This feature permits the steering wheel to be positioned so that one spoke is pointing down or toward the seat where the wheels are pointed straight ahead. Let's see how this steering wheel is removed.

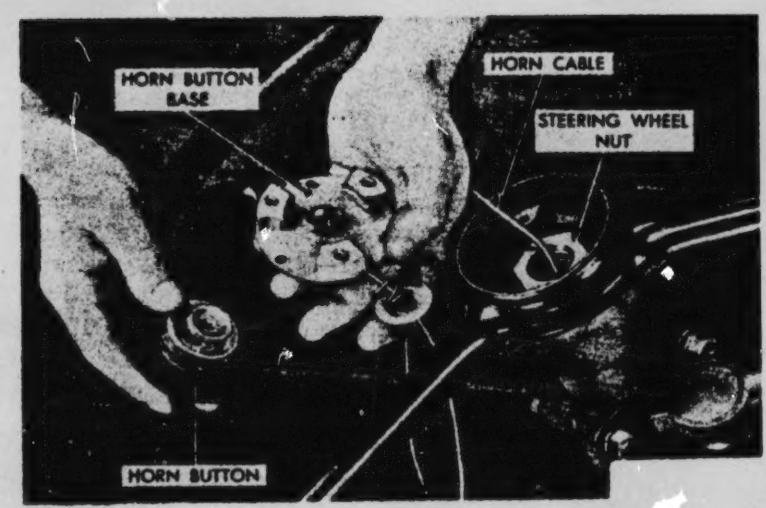
(1) If the steering wheel is not positioned properly, note the amount that it is off when you drive the truck on a straight road. Then turn the steering wheel to this same position before you remove it.

(2) Next, disconnect the negative ground battery cable (rear battery). Leave the ground cable off during the steering wheel removal procedures.

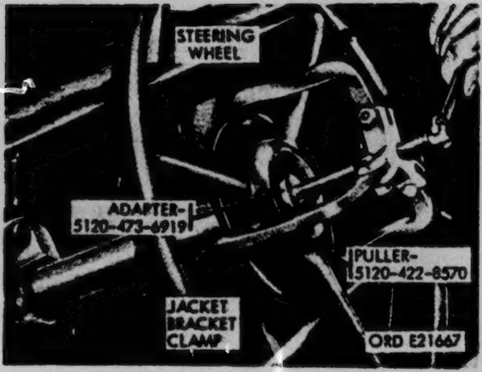

CUP, SPRING AND CONTACT
HORN BUTTON
ORD E19111

(3) Then remove the horn switch (button) by first pushing in with the palm of the hand. Then turn it counterclockwise (to the left) 1/3 turn and lift the button from the steering wheel. Next, remove the three screws from the horn button base and remove the base. The electrical cable can be left in the tubular shaft on most 2-1/2-ton trucks. On some vehicles the cable and base are made up as one unit and the cable must be removed with the base.

(4) Once the horn button base is removed, you can remove the nut that holds the steering wheel on the steering gear shaft.


HORN BUTTON BASE
HORN CABLE
STEERING WHEEL NUT
HORN BUTTON

(5) The steering wheel must be removed with a puller. The puller you should use has two adapters. One adapter is used under the steering wheel spokes. The other adapter goes between the puller screw and the steering gear shaft. Before you pull the steering wheel, make sure that you have the front wheels turned straight ahead.

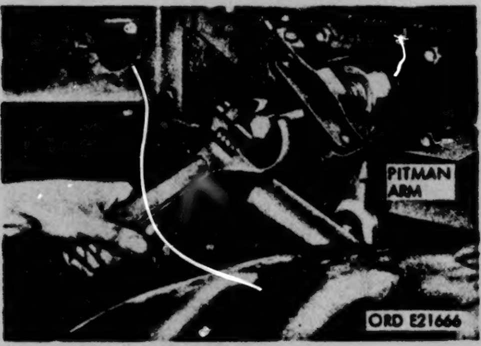


(6) Next, turn the puller screw clockwise and remove the steering wheel. Remove the puller from the wheel and you have completed the removal procedures.

b. Before installing the replacement wheel, inspect the spline and thread condition. If either is damaged beyond use, you must replace the steering gear assembly.

c. Install the replacement steering wheel with one spoke pointing down. Make sure you have the splines alined and the steering wheel pushed on as far as possible. Then install the nut and tighten it securely. Turn the steering wheel to each end of its travel to make sure there is no binding. If the new wheel binds, you may have to loosen the steering shaft tube (jacket) at its mounting points and slide it down slightly. This will increase the clearance between the tube and the steering wheel. Once the steering wheel is free of binding, install the horn parts and connect the battery cable and you are finished.

10. STEERING GEAR REPLACEMENT. Now that we know how to adjust the steering gear and know how to remove the steering wheel, let's try a bigger job. Let's remove and replace the steering gear. To remove and replace the steering gear on a 2-1/2-ton truck M34, M35, M35A1, M35A2, or M47, use the following procedures as a guide. (The engine must be removed from vehicles equipped with multifuel engines before replacing the steering gear.)



a. First, disconnect the drag link at the pitman arm end. Then remove the nut and washer holding the pitman arm in position. Pull the pitman arm from the shaft with a puller. Then remove the steering wheel as outlined in paragraph 9 above.

b. Next, remove the lockwasher and screw to loosen the steering gear jacket bracket clamp on the jacket bracket at the instrument panel. Then remove the rubber bushing from the bracket and jacket. Remove the four self-tapping screws that hold the gasket pad to the dash panel and remove the pad. Disconnect the horn wire (cable).

c. Remove the four bolts that hold the steering gear to the frame. Pull the steering gear away from the frame. Slide the gear down so that the steering gear jacket will clear the dash panel, and remove the steering gear from the vehicle.

d. Slide the new steering gear into position with the steering gear jacket extending through the opening on the dash panel. Insert the pitman arm shaft through the hole in the frame side member. Secure the steering gear to the side member with the four self-locking hex-head bolts, but do not tighten the bolts at this time.

e. Install the jacket pad and rubber bushing on the jacket. Position the bushing in the jacket bracket on the instrument panel. Secure the bracket clamp over the bushing with the hex-head screw and lockwasher. Secure the bracket to the dash panel with four cross-recess panhead tapping screws. Torque the steering gear housing-to-frame mounting bolts to 60 - 65 lb-ft.

f. Turn the steering gear to the midposition (high point), and make sure that the wheels are straight ahead. Install the pitman arm on the pitman arm shaft, with the ball stud end pointing downward, and secure it with the nut and lockwasher. Then connect the drag link to the pitman arm ball. Adjust the drag link end and install a cotter pin, locking it in place. Finally, install the steering wheel and horn button. Make sure that one spoke of the wheel points straight down when the wheels are straight ahead.

g. Fill the steering gear with lubrication and make an operational check of the installed steering gear before the vehicle is turned over to the operator.

SECTION IV. CONCLUSION

11. SUMMARY. We have learned that steering systems of wheeled vehicles are affected by some unwanted problems. There are certain terms we use to identify some of the factors that affect the steering of the vehicle. Examples of these terms are "shimmy" and "wandering." On the 1/4-ton truck we learned that, as a wheeled vehicle mechanic, you are authorized to inspect the steering gear and replace the steering wheel. Although the wheeled vehicle mechanic is not responsible for adjustments on the 1/4-ton truck steering gear, it was covered in this lesson for personnel who may assume the responsibility later in their career. We also learned how to make the cam end play and the backlash adjustments and how to replace the steering gear on the 2-1/2-ton truck. Without doubt, the inspection procedures we have learned on steering gears are important maintenance functions. A good inspection can save lives.

12. PRACTICE TASKS. The appendix of this lesson contains a list of tasks associated with the maintenance of mechanical steering gears. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all of the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist who is qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

46. An operator of a 1/4-ton truck explains that his front wheels seem to shake sideways as he drives down the road. He also explains that when this happens, the steering wheel moves from side to side and tries to pull out of his hands. Which unwanted steering factor best describes this problem?

    a. Wheel tramp
    b. Shimmy
    c. Erratic steering

47. When road testing a 2-1/2-ton truck M35A2, you find that the truck tries to turn too short when you make a turn. A close inspection in the shop shows that the steering gear mounting bolts are very loose. What steering factor should be used to best describe the steering problem in the turn?

    a. Drive
    b. Wandering
    c. Hard steering

48. What steering gear component(s) on the 1/4-ton truck M151 can be used to change the lash clearance between the teeth of the worm and roller?

    a. Screw
    b. Shims
    c. Nut

49. Why is one double-width serration cut on the sector shaft of a 1/4-ton truck M151?

    a. Increase the strength of the shaft
    b. Insure correct installation of the pitman arm
    c. Insure correct shaft end play adjustment

50. The steering gear on the 1/4-ton truck is called a worm and double roller because

a. there are two teeth on the sector.
b. there are two sets of bearings.
c. two tapered studs are used.

51. What is the maximum number of oil seals that should be inspected for leaks on the steering gear of a 1/4-ton truck M151?

a. 2
b. 3
c. 4

52. The horn button or switch on the steering wheel of the 1/4-ton truck M151 is held in place by

a. a setscrew.
b. three lugs.
c. a snapring.

53. You are installing a replacement steering wheel on a 1/4-ton truck M151. You have just tightened the retaining nut to the right torque valve. What additional action should be taken to assure that the nut will not accidentally loosen?

a. Rivet the shaft over the nut
b. Stake the nut to the shaft
c. Install a second retaining nut

54. As an organizational wheeled vehicle mechanic, what action should you take when you find a steering gear on a 1/4-ton truck M151 with too much free play?

a. Adjust the worm and roller lash
b. Replace the steering gear assembly
c. Notify support maintenance personnel

55. What is the main purpose of loosening and then retightening the steering gear mounting bolts before a worm bearing adjustment is made on the M151 steering gear?

a. Allow the steering shaft to center itself on the upper end of the steering jacket
b. Make sure the steering gear is not mounted in a bind
c. Assure that the mounting bolts are torqued to the right amount

56. The steering gear worm bearing adjustment on a 1/4-ton truck M151 is correct when the spring scale reading is between

a. 1.0 and 4.5 ounces.
b. 5.0 and 15.4 ounces.
c. 16.0 and 22.0 ounces.

57. In order to remove the steering gear from the 1/4-ton truck M151, it is necessary to disconnect the front wiring from the

a. instruments and gages.
b. instrument panel lights.
c. stoplight switch.

58. What type of steering gear is used on the 2-1/2-ton truck M35A2?

a. Worm and sector
b. Worm and roller
c. Cam and lever

59. What must be disconnected before adjusting the steering gear on a 2-1/2-ton truck M35A2?

a. Horn wire
b. Tie rod
c. Drag link

60. In order to make a steering gear cam end play adjustment on the cam and lever type gear of the 2-1/2-ton truck, it is necessary to

a. disconnect the upper cover.
b. tighten the adjusting screw.
c. remove the lower end plate.

61. What should be done if the steering gear cam bearings are too loose on a 2-1/2-ton truck M35A2?

a. Remove shims
b. Add shims
c. Replace the bearings

62. A mechanic is adjusting the worm and roller backlash on a 2-1/2-ton truck M35A1. He has turned the steering wheel to the extreme right of its travel. He is adjusting the backlash so that there is a slight drag on the steering wheel in this position. Which condition will be the result of this adjustment?

   a. The steering wheel will be very hard to turn at the extreme left of its travel, but otherwise will be all right
   b. The steering gear will be in proper adjustment throughout all the travel
   c. The steering wheel will be very hard to turn when the wheels are straight ahead

63. What item must be in the drag link when it is installed on the pitman arm of the 2-1/2-ton truck?

   a. Adjusting plug
   b. Ball seat
   c. Safety plug

64. Which statement is true when replacing the steering wheel on a 2-1/2-ton truck M35A2?

   a. The puller assembly is attached to the steering wheel with two capscrews
   b. The horn button can be removed from the steering wheel by first removing three screws
   c. The steering wheel can be installed in various positions due to equal sized splines

65. With the front wheels of a 2-1/2-ton truck M35A2 in the straight-ahead position and the steering wheel in the midposition, the pitman arm should be installed with the ball end pointing

   a. to the front.
   b. straight up.
   c. straight down.

APPENDIX

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PRACTICE TASK LIST

Practice Objective . . . . After practicing the following tasks you will be able to:

1. Inspect the mechanical steering gear of a wheeled vehicle.
2. Locate the adjustments on mechanical steering gears.
3. Troubleshoot steering gear problems.
4. Perform an operational check on steering gears.

Practice Tasks.

1. Inspecting, adjusting, and replacing components are the most important tasks you will probably perform on the steering gears of wheeled vehicles. In order to do a thorough job on the tasks listed below, refer to the procedures covered in this lesson and to the appropriate vehicle technical manuals and lubrication orders.

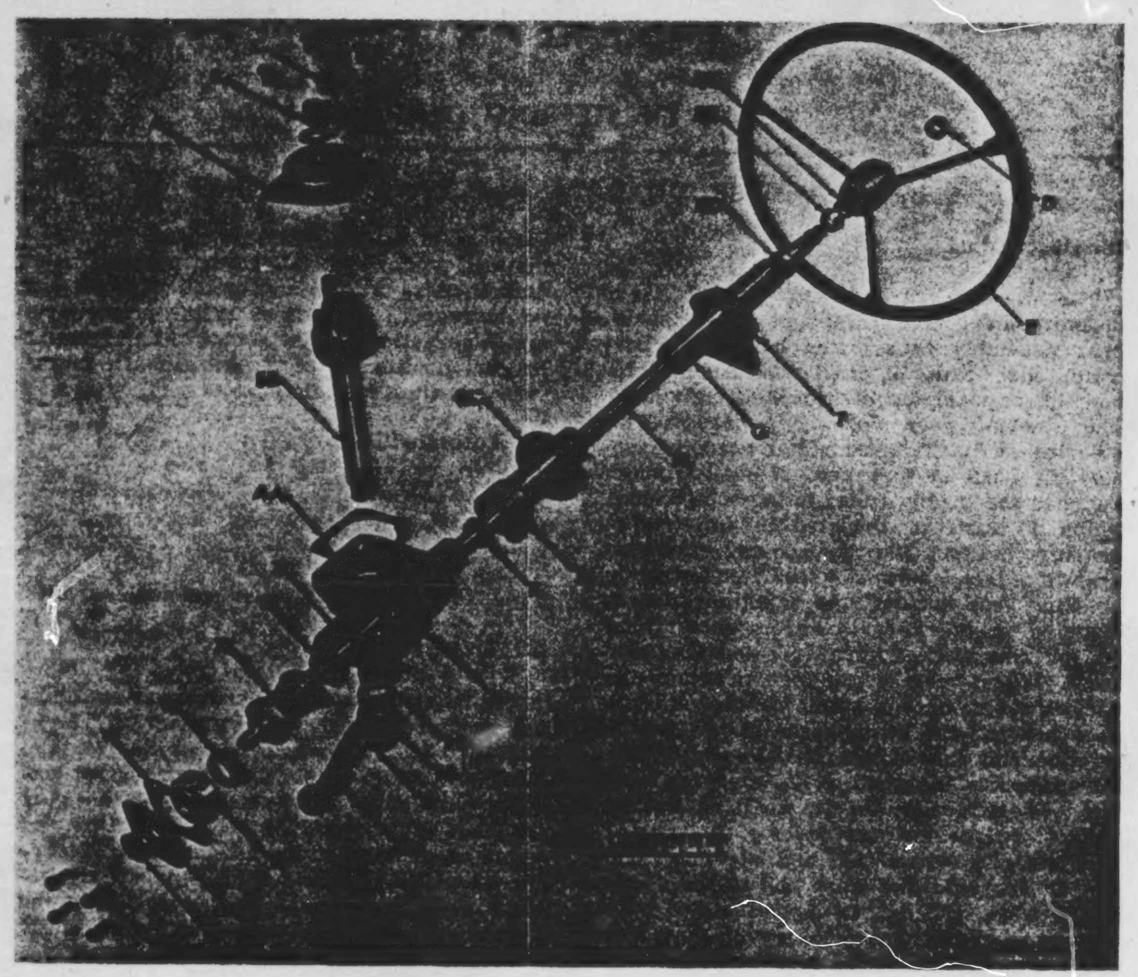
a. Inspect the steering gear on some of the different types of wheeled vehicles in your organization. Look for oil leaks, especially around the steering gear housing gaskets, covers, and seals. Check all mounting bolts, nuts, washers, and cotter keys. Check for any looseness or binding while turning the steering wheel back and forth. Check the lube level in the steering gear housing. Check for proper alinement of the steering gear shaft by loosening the clamp on the steering column at the instrument panel and see if it shifts position.

b. Determine what type of adjustments are used on the steering gears. You may find some vehicles with a large rotating adjusting device instead of shims to adjust the worm bearing clearance. Notice how the adjustments are locked on the different types of vehicles.

c. Check out the steering gears to see if they are working properly. See how much play each steering wheel has in the center of its travel. See if you can find the high point in each steering gear. If possible, help an experienced mechanic or repairman troubleshoot a defective steering gear or one that is not working right.

d. Whenever possible, drive various vehicles in your organization and see if the steering systems work as they should. Look for any factor that may cause bad steering, such as wander, shimmy, side pull, or looseness.

2. If you find any steering gears that are not working properly, notify your supervisor of the problem.



Legend:

Key	Item	Part Number	Key	Item	Part Number
A	Housing cover assy	7087516	S	Housing cap	7979489
B	Lock nut	96906-35691-822	T	Seal	7703446
C	Screw	8705446	U	Screw	8705446
D	Nut	7063812	V	Gasket	7342818
E	Steering wheel	8342301	W	Roller bearing	705009
F	Bracket	8754465	X	Worm gear	7979480
G	Tube and bearing assy	7059386	Y	Roller bearing	705009
H	Steering shaft	7059385	Z	Bearing cup	707077
J	Tube clamp assy	8705448	AA	Housing cover gasket	7087517
K	Seal	7703445	BB	Sector shaft	7059384
L	Steering gear housing	7087513	CC	Seal	8754466
M	Seal	7703447	DD	Bearing (part of tube and bearing assy)	
N	Lockwasher	8705452			
P	Nut	8705447	EE	Retainer	7979485
Q	Pitman arm	8754490	FF	Spring	7979478
R	Bearing cup	706619			

Foldout illustration No 1. Steering gear - exploded view

ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B207

POWER-STEERING

LESSON 4
MAINTENANCE OF POWER STEERING GEARS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B207 . . . Wheeled Vehicle Steering Systems

Lesson 4 . . . . Maintenance of Power Steering Gears

Credit Hours . . . . Two

Lesson Objective . . . . After studying this lesson you will be able to:

1. Explain the use of the common types of hydraulic system diagrams.
2. Interpret common symbols used in hydraulic system diagrams.
3. Describe the general procedures for troubleshooting hydraulic systems.
4. State the location of the hydraulic steering system components of the 5-ton truck.
5. Describe the procedures for inspecting the power steering system of the 5-ton truck.
6. Describe the procedures for isolating faults in the power steering system of the 5-ton truck.

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7. Describe the procedures for replacing a pitman arm and drag link.

8. Describe the procedures for replacing a power steering cylinder.

Text	Attached Memorandum
Materials Required	Answer sheet and response list
Suggestions	Study all illustrations, foldouts, and tables as well as the printed material.

FOREWORD

Power steering is an important aid to the driver of a heavy wheeled vehicle. In addition to providing the driver with an assist when he turns the steering wheel, the hydraulically operated power piston acts as a shock absorbing cushion to reduce the effects of road shocks.

As you know, when a front wheel hits a bump or hole in the road it tends to stop or turn in another direction. The wheel's movement is transmitted through the linkage and the steering gear to the steering wheel. This movement can be violent and can jerk the steering wheel from the driver's hands. This action is called road shock.

With power steering, however, road shock is practically eliminated. When the front wheel hits a bump it cannot turn the steering gear much because, in order to do so, it must move the power cylinder piston. The front wheel will actually move the steering worm or cam slightly, but when it does, it also moves the hydraulic control valve. High pressure oil then flows through the valve to the other side of the piston and this will tend to stop any further movement of the steering gear. In this manner we get a shock absorbing action from the hydraulic piston which practically eliminates road shock. However, if the power assist stops working, the resistance of the power piston will make it almost impossible for the driver to steer the vehicle. The system will then have to be repaired immediately.

ATTACHED MEMORANDUM

SECTION I. FUNDAMENTALS OF HYDRAULIC SYSTEM MAINTENANCE

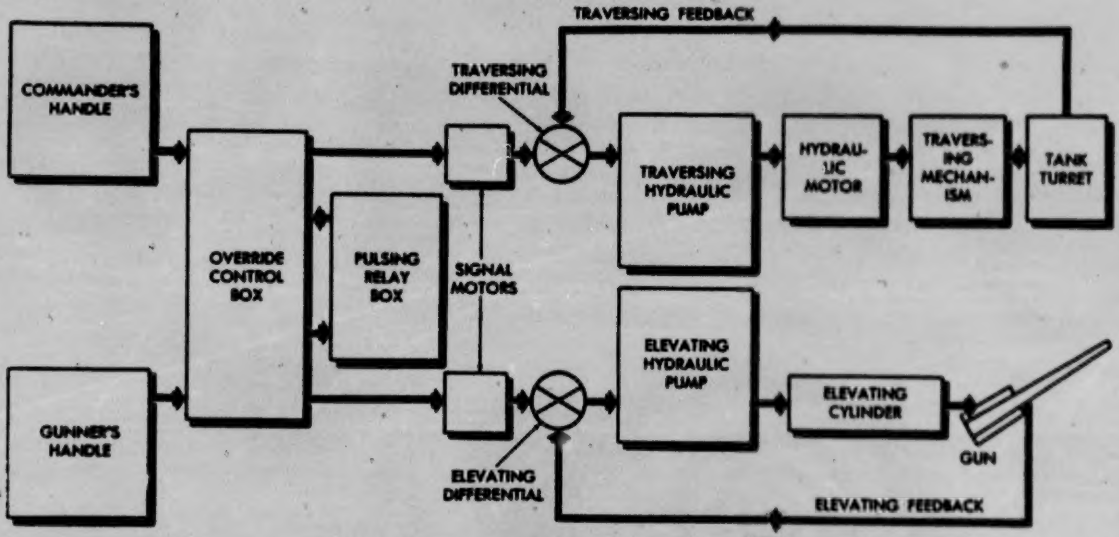
1. INTRODUCTION. In order to figure out how a certain television set works and to find out what is wrong with it when it doesn't work right, the TV repairman must be able to read electrical diagrams. The diagrams show him what each tube, resistor, etc, is supposed to do; how they are connected in the circuit; and the paths that the electricity follows. To a person with no knowledge of electrical diagrams, they are just a bunch of funny-looking lines drawn on a piece of paper, having no meaning. The repairman must learn to read signs in diagrams just as he has to learn to read printed words.

a. Hydraulic power steering systems, dump bodies, etc, on wheeled vehicles are shown by hydraulic circuit diagrams just as television sets, radios, etc, are shown by electrical circuit diagrams. A hydraulic circuit diagram is a complete drawing of a hydraulic circuit showing the reservoir, pump, valves, work cylinders or motors, and connecting lines.

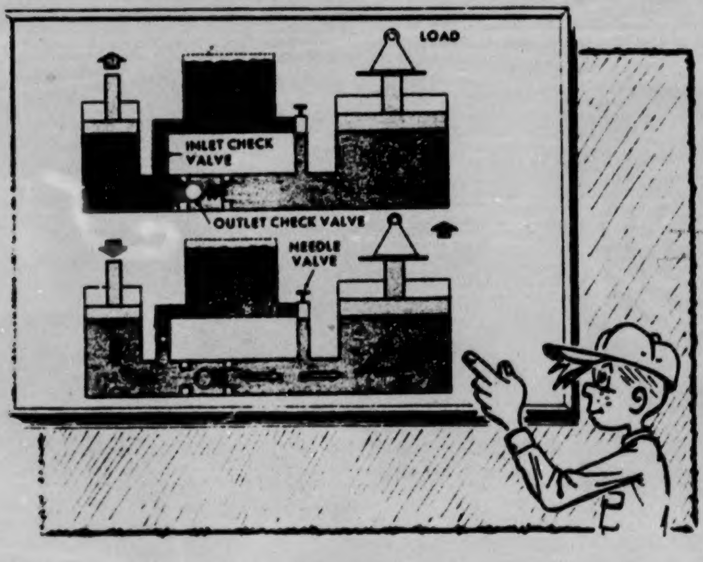
b. Accurate diagrams of hydraulic circuits are very useful to the mechanic. He can use them to find out what each part should be doing and where the oil should be going in each operation. Without knowing this, it is unlikely that the mechanic will be able to find out why a hydraulic system doesn't work as it should.

2. KINDS OF HYDRAULIC DIAGRAMS. Basically, there are four kinds of diagrams. They are the block, cutaway, pictorial, and graphical diagrams. The kind of diagram used will depend on what it is supposed to show. The mechanic should become familiar with all four kinds so that he can take advantage of all the information presented.

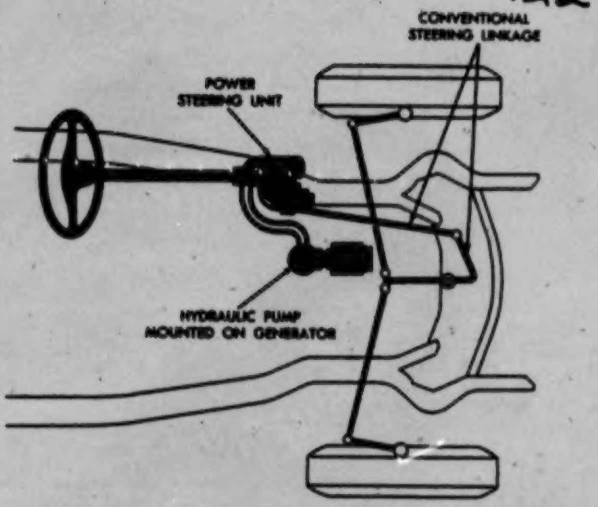
a. The block diagram shows the parts used in the system by blocks, with lines drawn between the blocks to show the connection between parts. The blocks may be drawn in the general shape of the parts they show, but it is not necessary. Each block is usually labeled so that you will know what part it represents. The mechanic can use this kind of a diagram to find out what parts the hydraulic system uses and how the lines are connected.


TRAVERSING FEEDBACK
COMMANDER'S HANDLE
TRAVERSING DIFFERENTIAL
OVERRIDE CONTROL BOX
PULSING RELAY BOX
SIGNAL MOTORS
TRAVERSING HYDRAULIC PUMP
HYDRAULIC MOTOR
TRAVERSING MECHANISM
TANK TURRET
ELEVATING HYDRAULIC PUMP
ELEVATING CYLINDER
GUN
GUNNER'S HANDLE
ELEVATING DIFFERENTIAL
ELEVATING FEEDBACK

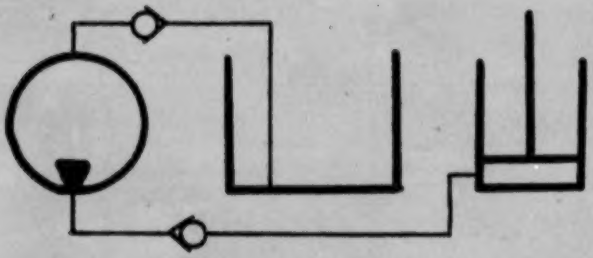
b. The cutaway diagram has been used a lot in other lessons in this subcourse. They are ideally suited for instruction since they show how the parts are made on the inside as well as show the flow paths of fluid. By using colors, shades, or various patterns in the lines and passages, many different flow and pressure conditions can be shown. Cutaway diagrams, however, cost a lot of money to make and take a lot longer to prepare, so they are not used as much as we might like.


LOAD
INLET CHECK VALVE
OUTLET CHECK VALVE
NEEDLE VALVE

c. Pictorial diagrams are made to show the actual arrangement and location of the parts contained in a hydraulic system. The parts of the system are drawn to look close to their actual shape and related size. The pictorial diagram is most useful to the wheeled vehicle mechanic when he is trying to locate the actual parts on the vehicle.


CONVENTIONAL STEERING LINKAGE
POWER STEERING UNIT
HYDRAULIC PUMP MOUNTED ON GENERATOR

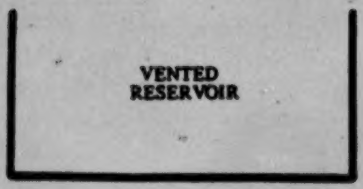
d. Graphical diagrams are the "short hand" method of showing hydraulic systems and are usually preferred for troubleshooting. A graphical diagram is made up of simple symbols or figures to show the pumps, valves, cylinders, lines, etc. It is not intended to show any detail about the construction or physical location of the system parts. It is used to show functions, part connections, and flow paths. Of course, to read the diagram one must know what each symbol means.



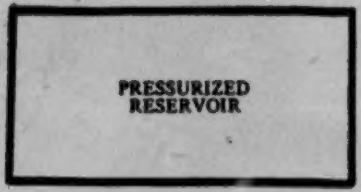
3. SYMBOLS.

a. There are three systems of symbols. Probably the most commonly used are the new USASI (United States of American Standards Institute) symbols. You may see diagrams using the old ASA (American Standards Association) or JIC (Joint Industry Conference) symbols. There are many differences between the systems, but if you know the new USASI system you will be able to figure out the others. The paragraphs below describe the USASI symbols that are most commonly shown in diagrams of hydraulic systems in automotive vehicles.

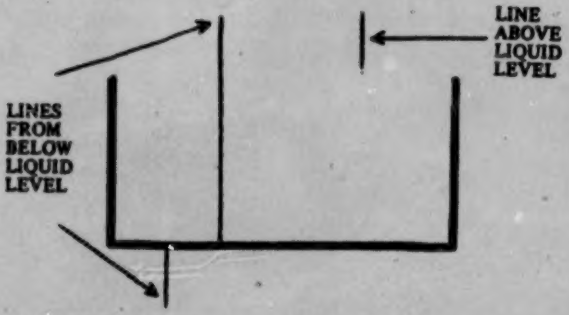
(1) A reservoir vented to the outside air is shown by a rectangle missing the top side. The long closed side of the symbol shows the bottom of the reservoir. The top of the symbol is open merely to show that the reservoir is vented and not that it has an open top.



(a) If the reservoir is pressurized it will not have a vent, so then the reservoir symbol will be closed at the top.

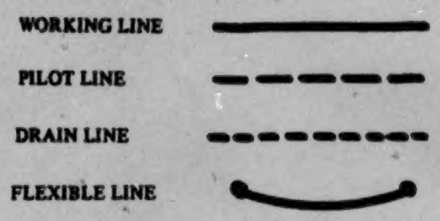


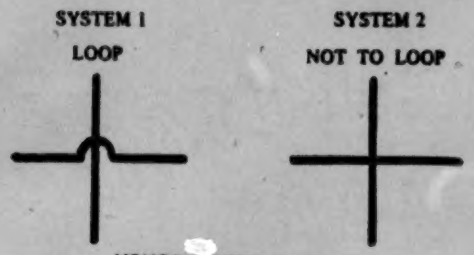
(b) Lines connected to the reservoir are drawn from the top, regardless of where the actual connections are, except when the pump depends on gravity for priming. Then the suction line is drawn from the bottom of the symbol. If the tip of the line is below the fluid level, it is drawn to touch the bottom of the symbol. Vent lines and fluid return lines that are above the fluid level are drawn from the top of the symbol without extending inside it.



(c) Every reservoir has at least two hydraulic lines connected to it and some have many more. Often the parts that are connected to the reservoir are spread out all over the diagram. If the lines from all the parts were drawn to one central reservoir symbol, the diagram would be harder to follow. Therefore, a reservoir symbol is usually drawn next to each part that is connected to it, but keep in mind that the reservoir is only one component that is pictured more than once.

(2) A hydraulic pipe, tube, or hose that carries the liquid is drawn as a single line. A working line, such as the suction and pressure, is drawn as a solid line. Pilot or control lines are broken into long dashes. Drain lines are broken into short dashes. A flexible line is drawn as an arc between two dots and will always be a solid line regardless of its purpose.

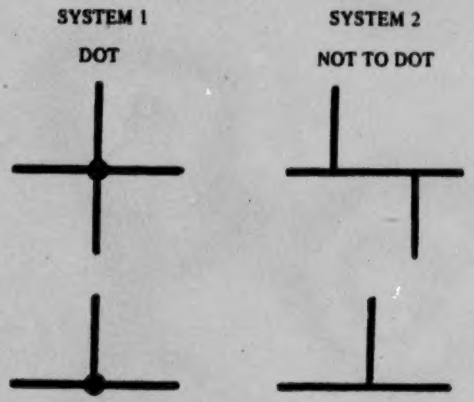




NONCONNECTING LINES

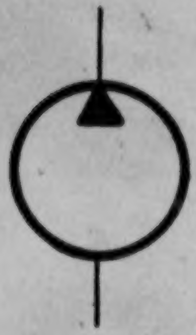
(a) Lines are drawn as straight as possible and are crossed only when absolutely necessary to make diagrams easier to reach. When lines do cross, you have to be able to tell if they are connected or not. Two systems are used to show that crossed lines are not connected. In one system a short loop is put in one of the lines at the point of crossing. The second system is to simply let the lines cross. Only one system is used in any single diagram.

(b) Two systems are also used to show a connection between crossed lines. One system is to place a dot at the crossing. In the second system the dot is omitted, but all connected lines are shown as tees. That is, one line is drawn to touch another one but does not pass straight across it.



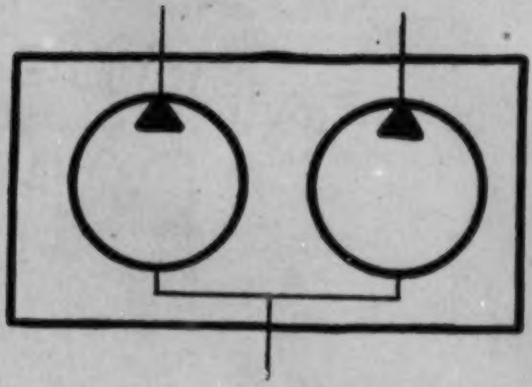
CONNECTING LINES

(3) The basic symbol for a pump is a circle with a black triangle pointed outward. There are a large number of different designs of pumps, such as the gear, vane, and reciprocating, but since they all have the same job, one symbol is all that is used. The black triangle points in the direction of flow. The pressure line is drawn from the tip of the triangle. The suction line is drawn from the opposite side of the pump.

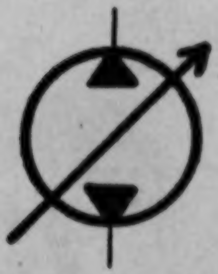


FIXED DISPLACEMENT PUMP

(a) Two pump symbols drawn inside a rectangle mean that a double pump is used. Double pumps are mounted on the same shaft and turn together. Usually they are made in one housing with separate outlets.



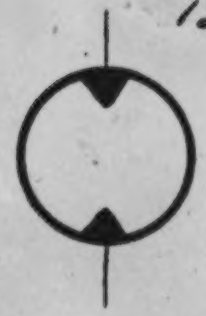
DOUBLE PUMP



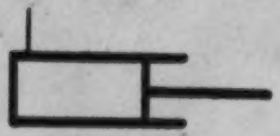
VARIABLE DISPLACEMENT PUMP

(b) If a pump's output is variable, it will have an arrow drawn through it at 45 degrees. Two black triangles in one circle mean that the pump's rotation is reversible.

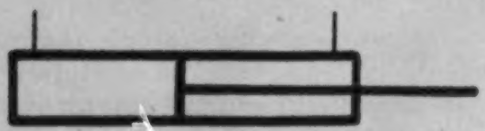
(4) Symbols for motors are circles with black triangles, but the triangles point in to show that the oil is forced into the motor. One triangle is used for a motor that will work in only one direction; two are used for a reversible motor. The tips of the triangles point in the direction of flow as it enters the motor.



REVERSIBLE MOTOR



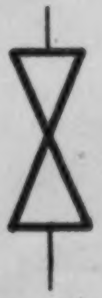
SINGLE-ACTING CYLINDER



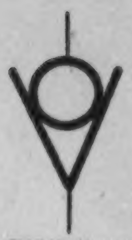
DOUBLE-ACTING CYLINDER

(5) A cylinder symbol is a simple rectangle that stands for the barrel and a T-shaped figure that stands for the piston and rod. If the cylinder is single-acting, only one hydraulic line is drawn to the symbol. Also, the end of the symbol opposite the line is left open. A double-acting cylinder symbol has both ends closed and two hydraulic lines drawn to it, one at each end. There are no marks drawn in the cylinder to show the direction of flow. This is really no problem, though, as the rest of the diagram symbols contain many arrows pointing in the direction of liquid flow.

(6) The reasons for using valves vary a great deal, so different symbols must be used for different types of valves to show their purpose in the hydraulic system. A manually operated shutoff valve with an on and off position is shown by drawing two triangles point to point. This symbol is for valves like the cock and gate.



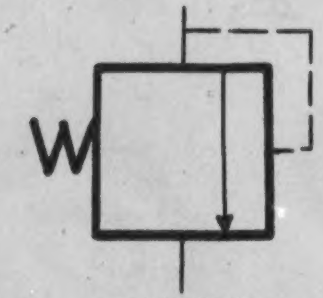
MANUAL ON-OFF VALVE



CHECK VALVE

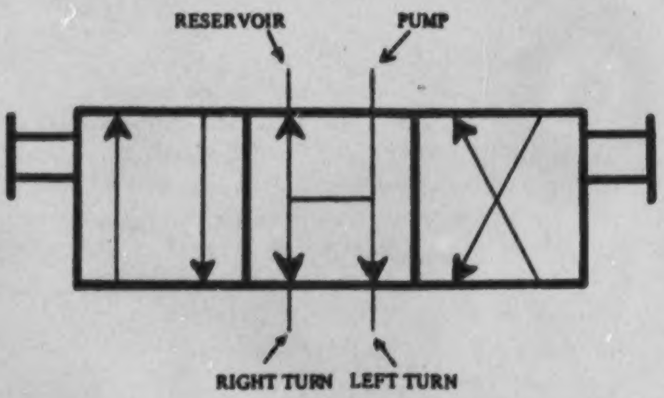
(7) The symbol for a check valve is a circle inside a V. This indicates a ball set against a ball seat, but does not necessarily mean that the valve is made this way. Don't mistake the V for an arrow showing the direction of flow. Free flow through the valve is out of the V toward the circle.

(8) The basic symbol for the relief valve is a square with an arrow inside to show the direction of flow. Usually this valve is held closed by a spring. The spring is shown by drawing a zigzag line at one side of the square. The inlet and outlet lines are then drawn out of line with the arrow to show that the valve is normally closed. To show that the valve is opened by hydraulic pressure, a dashed pilot line is drawn from the inlet line to the side of the square opposite the spring.



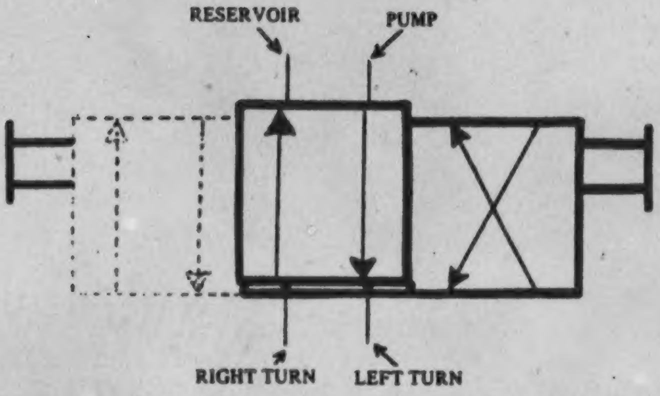
RELIEF VALVE

(9) A directional control valve symbol is a rectangle that has a section for each position of the valve. Connecting lines are only drawn to the section of the symbol that shows the neutral position. Each section of the symbol has arrows to show flow paths when the valve is shifted to that position. The arrow arrangement inside each section is drawn to display the functions of the specific valve that the symbol represents. The accompanying symbol shows the three-position spool-type control valve. Notice that the neutral section of the valve shows oil flow from the pump to the reservoir and left turn and right turn passages.



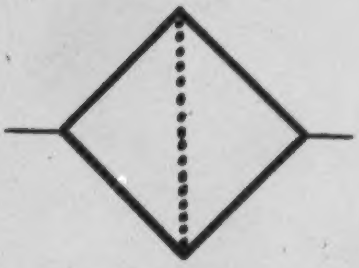
DIRECTIONAL VALVE (THREE POSITION)

(a) Now let's see how you should go about tracing oil flow through the control valve in the left turn position. It is obvious that we cannot actually shift or rearrange valve symbols that are already drawn on the diagram. We can, however, form a mental picture of how the passages will be connected if the valve was in another position besides neutral.

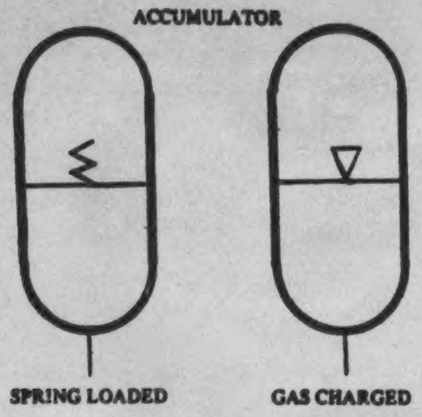


(b) This is done by imagining that you move the left turn section of the control valve symbol so that it covers the neutral section. The passages will then appear to be connected to the lines and arrows inside the left turn symbol. Notice that this shows oil from the pump being directed to one side of the power pistons to assist in turning left. Oil from the opposite side of the power piston is directed through the valve to the reservoir. Oil flow during the right turn is traced by mentally placing the right turn section of the symbol over the neutral section.

(10) If you should see a square symbol containing a dotted line between opposite corners, it will stand for an oil filter. The connecting lines will be drawn from the corners of the symbol so that they are crossways to the dotted line.



FILTER OR STRAINER



(11) An accumulator appears on a diagram as an oval and usually has figures added on the inside to show if it has a spring or a gas charge.

b. In the above paragraphs we have described the major graphical symbols. We have not tried to cover every possible symbol or the many possible variations. For your personal reference, all the USASI basic hydraulic symbols are included in foldout No 1 in the back of this supplemental pamphlet.

4. TROUBLESHOOTING. Hydraulic pumps, cylinders, motors, valves, etc, are precision units. Their continued smooth operation depends on performing inspections often and proper servicing of the hydraulic system. It is very important that they be kept clean and the oil and filters changed at the times recommended in the proper technical manuals.

a. When improper operation does occur, the cause can generally be traced to one of the following causes:

(1) Liquid used in the system that is of the wrong viscosity (thickness) or type.

(2) Not enough liquid in the system.

(3) Air in the hydraulic units or lines.

(4) Damaged or worn parts.

(5) Oil leaks, either internally or externally.

(6) Dirt, water, sludge, rust, metal cuttings, and other foreign matter in the system.

(7) Units and control linkage improperly adjusted.

(8) Equipment being operated improperly.

b. Troubleshooters should use a procedural system that will lead them directly to the cause of troubles, removing as much guesswork as possible. One such system could be called STOP, which is described as follows:

(1) S - Study the hydraulic circuit diagrams. You will find that knowing what each part in the system is supposed to do is probably the most vital part of troubleshooting.

(2) T - Test using all appropriate equipment and means that are available. You must know exactly what conditions exist in the system and how it reacts before accurate decisions can be reached.

(3) O - Organize the knowledge gained from the circuit diagram study and hydraulic system tests; then determine the cause of the trouble.

(4) P - Perform repairs taking time to do the job well.

c. The troubleshooting section in vehicle TM's contains a list of troubles (malfunctions) of the vehicle's hydraulic systems, the probable causes of the troubles, and the corrective repairs that should be made. You should always use this list to aid you in troubleshooting the vehicle. As a further aid to you, foldout No 2, in the back of this lesson, contains a list of common hydraulic system problems, their possible causes, and corrective actions or remedies.

SECTION II. MAINTENANCE OF THE ROSS HF-64 POWER STEERING SYSTEM

5. DESCRIPTION.

a. General. The steering system is comprised of a steering wheel, hydraulic assisted steering gear, hydraulic oil reservoir, hydraulic pump, power steering cylinder, control valve, relief valve, lines and fittings, universal jointed steering shaft, and steering linkage.

b. Steering wheel. The three-spoked, 18-inch, steering wheel is mounted on the upper end of the steering shaft and is secured by a hex-nut. The horn button is mounted in the center of the steering wheel.

c. Steering gear assembly. The steering gear unit is a fully integral steering gear incorporating a hydraulic control valve, power cylinder, and mechanical means of steering control. The power of the cylinder is transmitted to the steering gear output shaft by means of gear teeth on the piston mating with teeth on the shaft. The flow of oil from the engine-driven pump is directed to the power cylinder by means of the control valve. The valve is concentric with the input shaft and is located on the upper end of the steering gear.

d. Power steering pump and oil reservoir. The power steering pump and oil reservoir are mounted on left front side of the engine. The oil reservoir encloses the pump housing and provides a reserve supply of oil to assure complete filling of the hydraulic system. Atmospheric pressure in the reservoir is maintained through a vent near the filler neck of the reservoir. A filter is installed near intake of pump to prevent dirt or other foreign matter from entering the hydraulic system. The pump is driven by a double pulley and two V-belts from the engine accessory drive. For repair, replacement, and service notify direct support maintenance unit.

e. Steering linkage. The steering linkage consists of a pitman arm, drag link, steering knuckle arm, adjustable tie rod, and adjustable power cylinder. Adjustable spring-loaded ball seats at both ends of the drag link engage the pitman arm ball stud and ball stud on left steering knuckle arm. Spring-loaded ball seats at both ends of the power cylinder engage the ball stud on the spring shackle bolt and ball stud on the right steering knuckle arm.

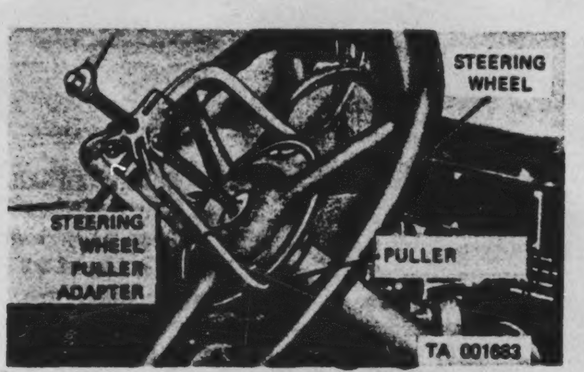
6. STEERING WHEEL.

a. Steering wheel removal.

(1) Remove horn button assembly.

(2) Remove hex-nut securing steering wheel to upper end of steering shaft.

(3) Using steering wheel puller adapter and puller, remove steering wheel from steering shaft.



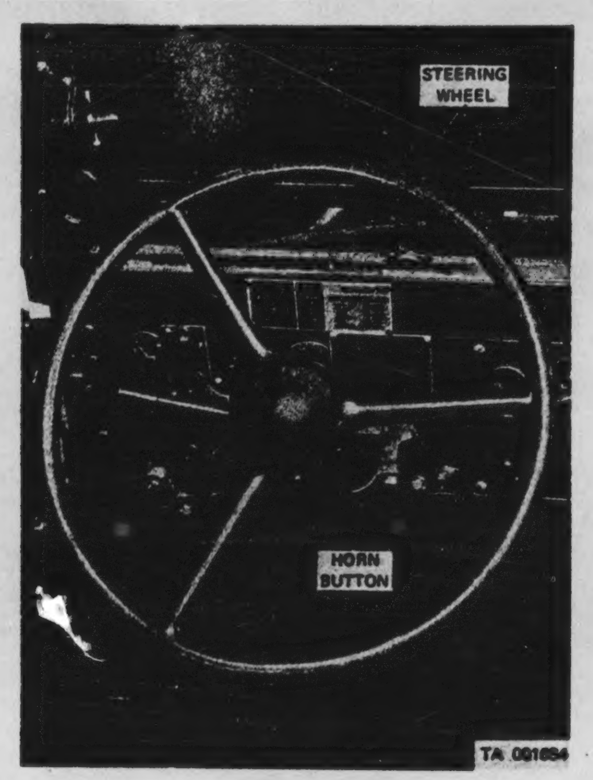
Steering wheel removal.

b. Steering wheel installation.

(1) Position steering wheel on upper end of steering shaft with splines on end of shaft engaging splines in bore of steering wheel hub. Steering wheel should be installed so that spokes form a Y when viewed from the driver's seat with the front wheels in straight-ahead position.

(2) Install hex-nut on steering shaft and torque to 55-65 ft lb.

(3) Install horn button assembly.



Steering wheel.

7. STEERING COLUMN BUSHINGS.

a. General. There are two steering column bushings: one mounted in a bracket on the vehicle instrument panel and the other mounted in a bracket on the vehicle firewall.

b. Removal of steering column bushings.

(1) Remove screw, washer, and nut retaining upper steering column bracket to engine compartment side of firewall.

(2) Remove screw retaining upper steering column bracket to upper steering column.

(3) Remove screw from clamp on steering column bracket that is mounted on firewall.

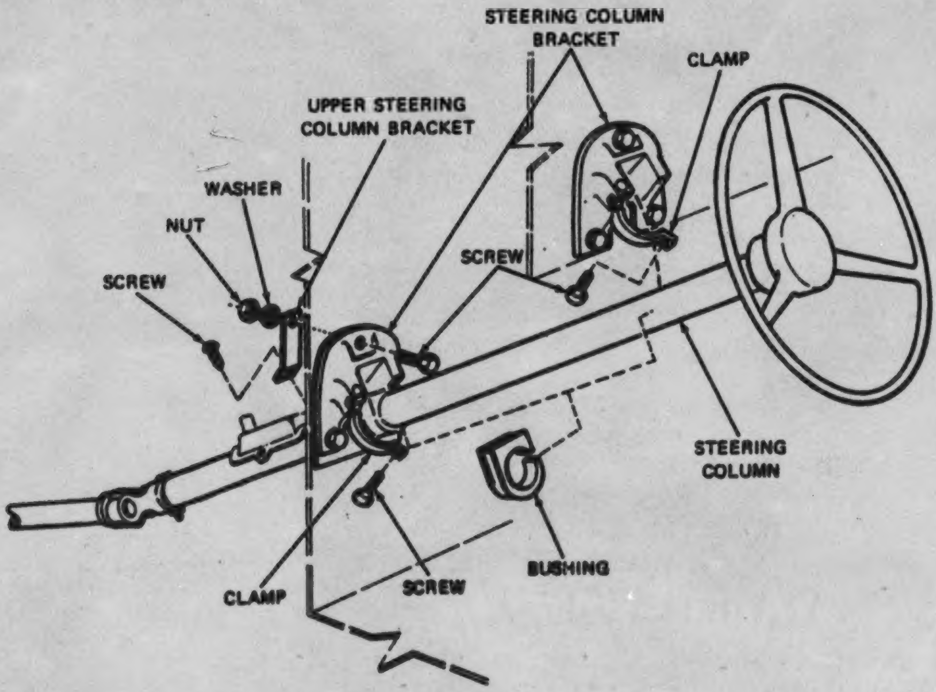
(4) Remove screw from clamp on steering column bracket that is mounted on instrument panel.

(5) Lower steering column. Remove and discard two steering column bushings.

c. Installation of steering column bushings.

(1) Install and position two new steering column bushings on steering column.

(2) Raise steering column and bushings into proper position in the two steering column brackets.


STEERING COLUMN BRACKET
CLAMP
UPPER STEERING COLUMN BRACKET
WASHER
NUT
SCREW
SCREW
STEERING COLUMN
BUSHING
CLAMP
SCREW

Steering column bushing removal and installation.

(3) Secure each steering column bracket clamp with a screw. 134

(4) Aline holes in upper steering column bracket with holes in firewall and secure with screw, washer, and nut.

(5) Install the screw retaining the upper steering column bracket to the upper steering column.

8. PITMAN ARM.

a. Pitman arm removal.

(1) Disconnect front end of drag link from pitman arm ball stud.

(2) Remove nut and lockwasher securing pitman arm to steering gear shaft.

(3) Remove pitman arm using a suitable puller.

b. Pitman arm installation.

(1) With front wheels straight ahead and the steering wheel in midposition, install the pitman arm on splined portion of steering gear shaft by alining index marks on shaft and arm.

(2) Place lockwasher and nut on threaded portion of steering gear shaft and torque nut to 475-500 ft lb.

(3) Connect front end of drag link to pitman arm ball stud.

9. DRAG LINK.

a. Drag link removal.

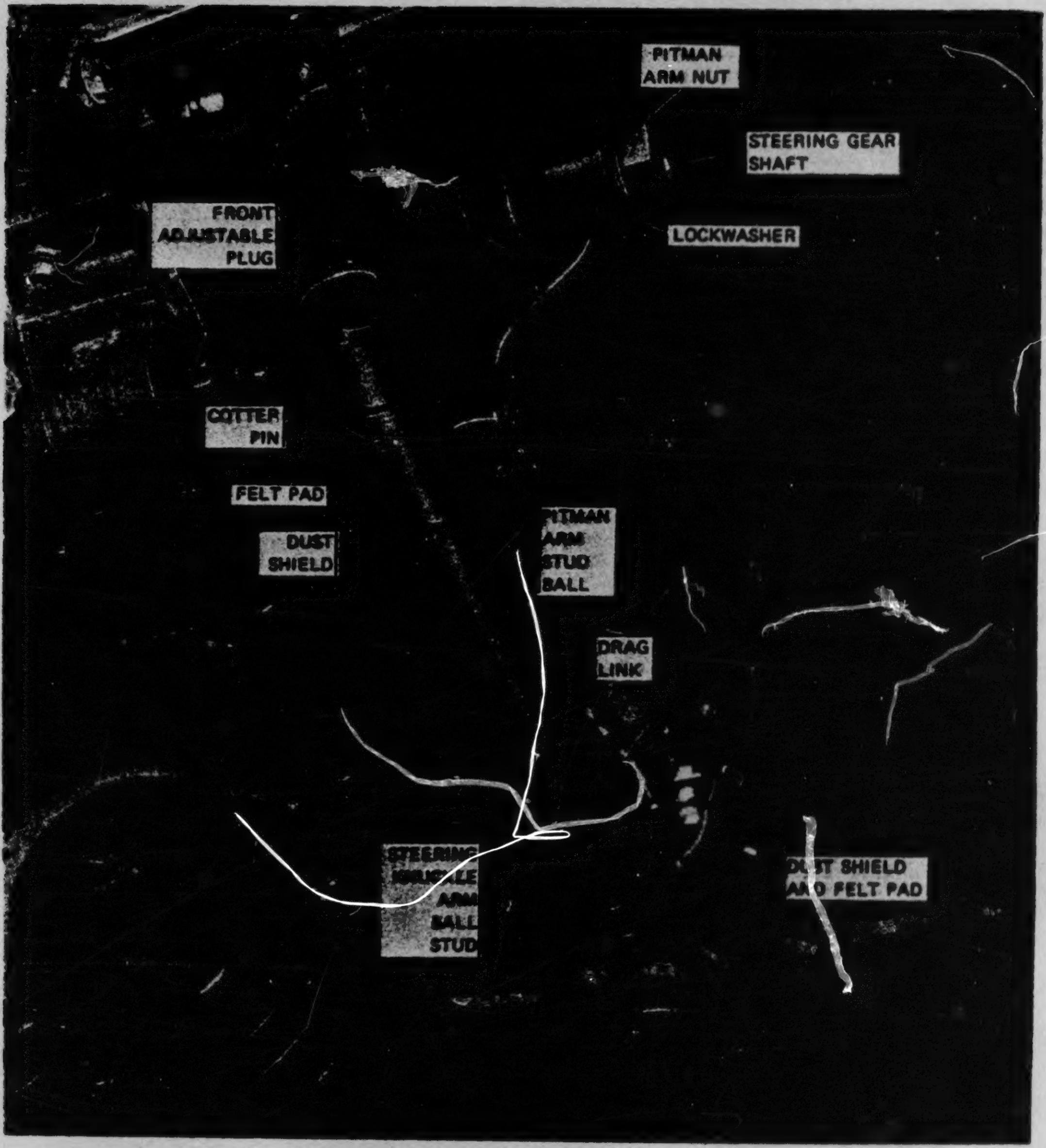
(1) Set front wheels in straight ahead position and steering wheel in midposition.

(2) Remove and discard cotter pins from both ends of drag link.

(3) Disconnect dust shield from both ends of drag link.

(4) Loosen adjustable plugs at both ends of drag link, but do not remove plugs.

(5) Turn steering wheel in both directions to loosen drag link ends. Remove front end of drag link from pitman arm ball stud and rear end of drag link from steering knuckle arm ball stud.


PITMAN ARM NUT
STEERING GEAR SHAFT
FRONT ADJUSTABLE PLUG
LOCKWASHER
COTTER PIN
FELT PAD
DUST SHIELD
PITMAN ARM STUD BALL
DRAG LINK
STEERING KNUCKLE ARM BALL STUD
DUST SHIELD AND FELT PAD

Steering linkage removal and installation.

Note. - If the adjustable plugs are removed, make sure that plugs and springs are kept free of dirt.

(6) Remove and discard dust shields and felt pads from pitman arm ball stud and steering knuckle arm ball stud.

b. Drag link installation.

Note. - Front end of drag link assembly is the end that has greatest distance between the ball stud opening and end of drag link.

(1) Install a new dust shield and new felt pad on the pitman arm ball stud and steering knuckle arm ball stud.

(2) Place drag link on pitman arm ball stud; make sure that drag link ball seats encircle pitman arm ball stud.

(3) Screw front adjustable plug into front of drag link, but do not tighten.

(4) Place drag link on steering knuckle arm ball stud; make sure ball seats encircle knuckle arm ball stud.

(5) Screw rear adjustable plug into rear of drag link tight onto the ball seats and then back off until slot in adjustable plug is alined with holes in socket. Install new cotter pin.

(6) Screw front adjustable plug into front of drag link tight onto ball seats and then back off until slot in adjustable plug is alined with holes in socket. Install cotter pin.

(7) Turn steering wheel in both directions to make certain that ball seats and ball studs are seated.

(8) Connect dust shield on both ends of drag link.

(9) Lubricate drag link according to LO 9-2320-260-12.

c. Drag link repair parts kit installation.

(1) Remove drag link assembly. Refer to paragraph a above.

(2) Remove and discard adjustable plugs from both ends of drag link.

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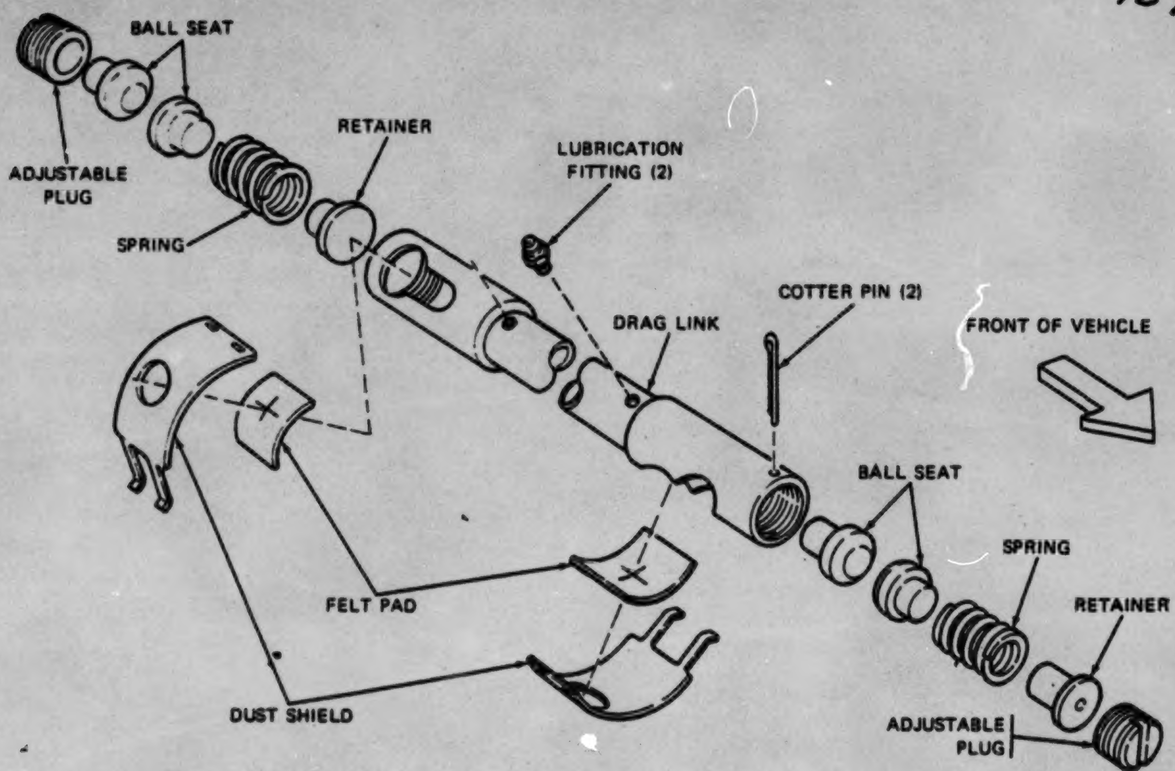

BALL SEAT
ADJUSTABLE PLUG
RETAINER
LUBRICATION FITTING (2)
SPRING
COTTER PIN (2)
DRAG LINK
FRONT OF VEHICLE
BALL SEAT
SPRING
RETAINER
FELT PAD
DUST SHIELD
ADJUSTABLE PLUG

Drag link— exploded view.

(3) Remove and discard retainer, spring, and two ball seats from each end of drag link.

(4) Install components of repair parts kit in drag link.

(5) Install drag link assembly. Refer to paragraph b above.

10. POWER STEERING CYLINDER.

a. Power steering cylinder removal.

(1) Remove shield guard.

(2) Remove two hoses from top of power steering cylinder.

Note. - When removing hoses have a suitable container (2-quart capacity) to drain the oil. Also, cap all hoses and ports immediately to prevent dirt or foreign matter from entering power steering system.

(3) Disconnect dust shield and felt pad. Remove cotter pin from front of power steering cylinder.

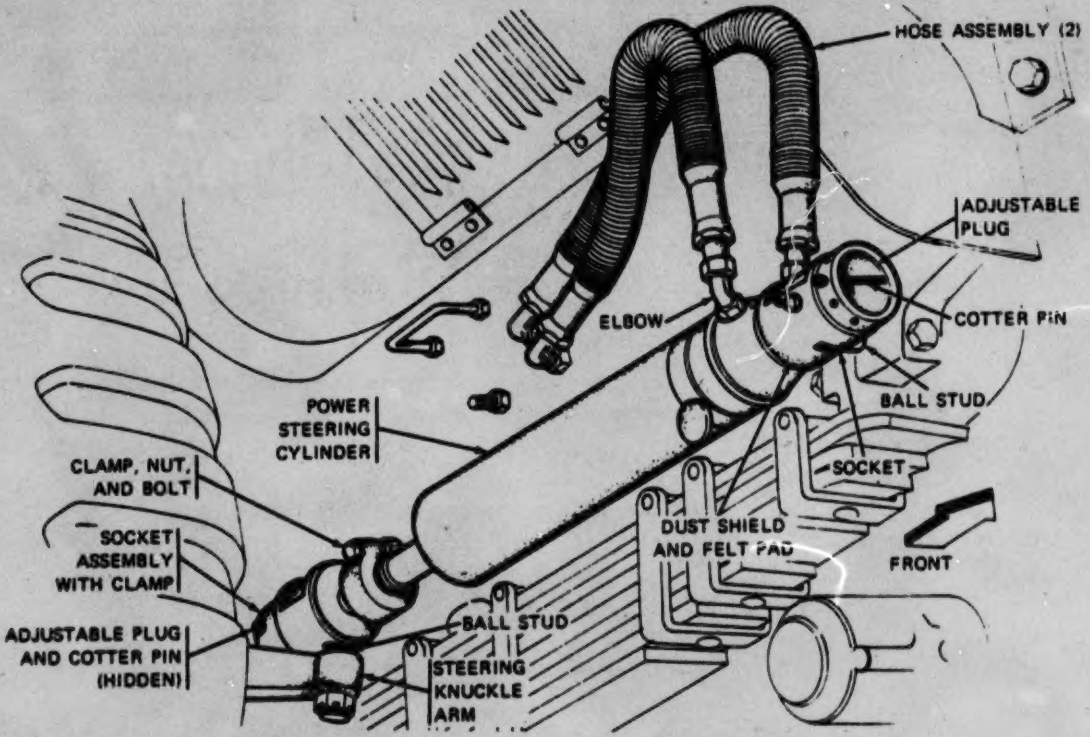
(4) Loosen front adjustable plug as far as possible without completely removing it from power steering cylinder.

(5) Remove dust shield and felt pad from socket at steering knuckle arm.

(6) Remove cotter pin from rear of power steering cylinder socket assembly.

(7) Loosen rear adjustable plug as far as possible without completely removing from power steering cylinder.

(8) Tap power steering cylinder at both ends to loosen ball seats from ball studs and remove power steering cylinder from vehicle.


HOSE ASSEMBLY (2)
ADJUSTABLE PLUG
COTTER PIN
ELBOW
BALL STUD
POWER STEERING CYLINDER
SOCKET
CLAMP, NUT, AND BOLT
DUST SHIELD AND FELT PAD
SOCKET ASSEMBLY WITH CLAMP
FRONT
BALL STUD
ADJUSTABLE PLUG AND COTTER PIN (HIDDEN)
STEERING KNUCKLE ARM

Power steering cylinder, hoses, and fittings.

b. Power steering cylinder travel adjustment.

Note. - The power cylinder is properly adjusted when, with wheels positioned straight ahead, the distance between centerlines of the spring shackle bolt ball stud and steering knuckle arm ball stud is 25.50 inches.

(1) Loosen clamping nut and bolt to release pressure on threaded end of power steering cylinder.

(2) Turn socket assembly counterclockwise to extend travel of power steering cylinder.

(3) Turn socket assembly clockwise to decrease travel of power cylinder.

(4) When travel of power cylinder has been adjusted, tighten clamp nut and bolt on threaded end of power steering cylinder. Torque to 85 ft lb.

c. Power steering cylinder installation.

(1) Position power steering cylinder ball seat on ball stud of spring shackle bolt; make sure that ball stud is encircled by ball seats.

(2) Screw in adjustable plug just enough to hold ball seats on ball stud.

(3) Position ball seats on ball stud of upper steering knuckle arm.

(4) Screw adjustable plug into rear socket tight onto ball seats and then back off until slot in adjustable plug is alined with holes in socket. Insert cotter pin.

(5) Screw adjustable plug into front socket tight onto ball seats and then back off until slot on adjustable plug is alined with holes in socket. Install cotter pin.

(6) Install two hoses on power steering cylinder. Be certain connections are clean and are tightened firmly.

(7) Install shield guard.

(8) Bleed steering system.

(9) Start engine; then turn steering wheels in both directions to check for proper adjustment of power steering cylinder and proper seating of ball seats on ball studs.

(10) Install dust shield and felt pad on both ends of power steering cylinder.

11. SOCKET ASSEMBLY.

a. General. The socket assembly with clamp is attached to rod end of power steering cylinder on one end and to steering knuckle ball stud on the other.

b. Removal of socket assembly with clamp.

(1) Disconnect dust shield and felt pad from socket.

(2) Remove cotter pin from socket.

(3) Loosen adjustable plug to allow ball seats to release steering knuckle ball stud.

(4) Remove socket from steering knuckle ball stud.

(5) Loosen clamping nut and bolt to release pressure on threaded end of power steering cylinder rod. Remove socket from rod.

(6) Remove and discard dust shield and felt pad.

c. Repair of socket assembly.

(1) Remove socket. Refer to paragraph b above.

(2) Remove and discard adjustable plug, two ball seats, and spring.

(3) Install a new spring, two ball seats, and adjustable plug.

(4) Install socket on power steering rod end. Refer to d below.

d. Installation of socket assembly with clamp.

(1) Thread socket on rod end of power steering cylinder.

(2) Position new dust shield and felt pad on steering knuckle ball stud.

(3) Install socket on steering knuckle ball stud. Refer to paragraphs 9c(3) through (5).

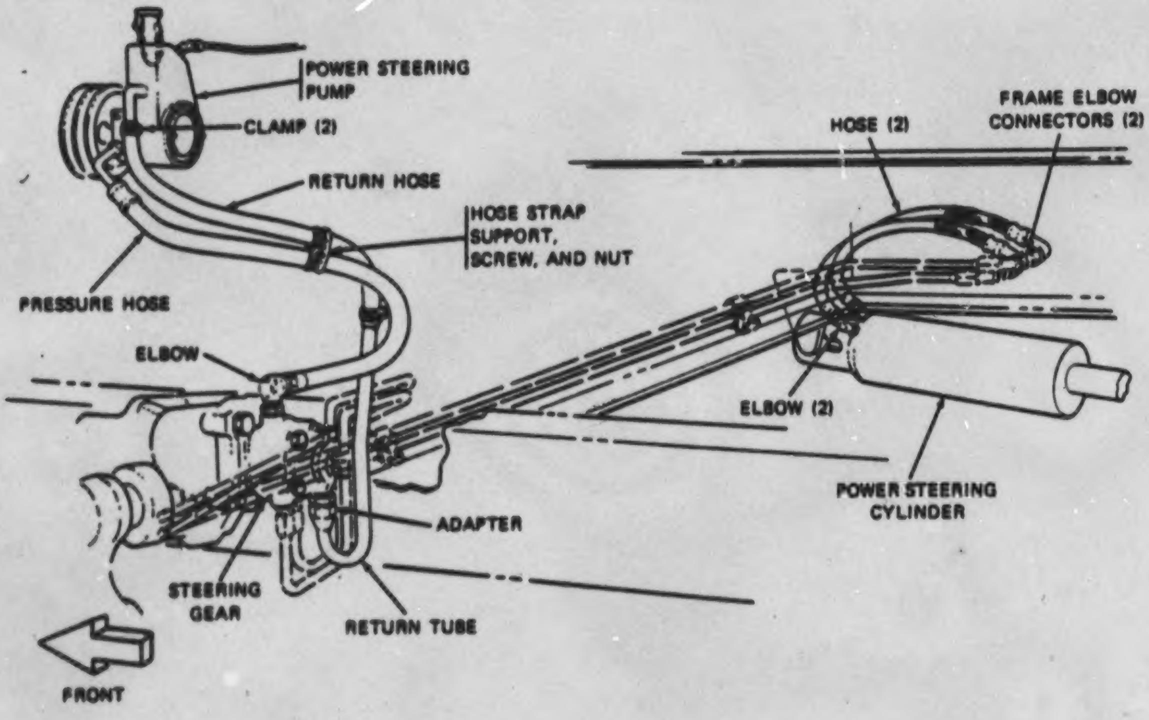
(4) Check and adjust travel of power steering cylinder as necessary. Refer to paragraph 9b.

(5) Secure dust shield and felt pad on socket.

12. HYDRAULIC HOSES, TUBES, AND FITTINGS.

a. Description. The components of the power steering hydraulic system are connected by a combination of tubes and flexible hoses. Inspect flexible hoses, tubes, and fittings for damage and leaks.

WARNING: Do not start engine after fittings are disconnected as the hose may whip and fluid escape under pressure causing injury to personnel. Before installing or connecting any fittings, hoses, or tubing be certain that all openings are clean and free from foreign matter. Failure to use precautionary measures to prevent foreign matter from entering power steering hydraulic systems may result in an accident, damaged equipment, or injury to personnel.


POWER STEERING PUMP
CLAMP (2)
RETURN HOSE
HOSE STRAP SUPPORT, SCREW, AND NUT
PRESSURE HOSE
ELBOW
HOSE (2)
FRAME ELBOW CONNECTORS (2)
ELBOW (2)
POWER STEERING CYLINDER
ADAPTER
STEERING GEAR
RETURN TUBE
FRONT

Power steering hydraulic system, hoses, tubes, and fittings—removal and installation.

Note. - Cap all open ports and hoses to prevent foreign matter from entering hydraulic steering system.

b. Removal of power steering pressure hose, return hose, and related parts.

(1) Remove steering gear shield guard.

(2) Drain hydraulic oil from power steering pump into suitable container (1 gallon minimum) by disconnecting pressure hose from elbow on steering gear.

(3) Loosen hose strap support holding pressure hose and return hose.

(4) Disconnect pressure hose from power steering pump and remove hose.

(5) Loosen hose clamps at upper and lower end of return hose. Remove hose and hose strap support.

(6) Disconnect return tube from adapter on steering gear and remove return tube.

(7) Remove elbow from top of steering gear and adapter from bottom of steering gear.

c. Installation of power steering pressure hose, return hose, and related parts.

(1) Install adapter in bottom of steering gear. Torque to 25-35 ft lb.

(2) Install elbow to top of steering gear. Torque to 25-35 ft lb.

(3) Install pressure hose, return hose, and return tube. Reverse removal procedure in (1) through (6) in b above.

(4) Add hydraulic oil, as necessary, to bring level of oil to full mark on oil reservoir sight gage.

(5) Start engine and run at idle speed for 2 or 3 minutes. Stop engine and add hydraulic oil if necessary.

(6) Start engine, run at idle speed, and turn wheels slowly from side to side several times to completely bleed air out of system. Place wheels in straight-ahead position. Stop engine and add hydraulic oil (if necessary) to bring level of oil to full mark.

d. Removal of power steering cylinder hose assemblies. Both hoses are removed in the following manner:

(1) Remove steering cylinder shield guard.

(2) Drain hydraulic oil from hoses into suitable container by disconnecting hose from elbow on steering cylinder.

(3) Disconnect hose from frame elbow connectors and remove hose.

(4) Remove elbow from steering cylinder.

e. Installation of power steering cylinder hose assemblies. Both hoses are installed in the following manner:

(1) Install elbow in steering cylinder. Torque to 25-35 ft lb.

(2) Install one end of hose to elbow on steering cylinder and the other end to the frame elbow connector.

(3) Install steering cylinder shield guard.

(4) Add hydraulic oil and bleed system. Refer to c(4) through (6) above.

13. INSPECTION. An inspection should begin by checking the level and condition of the steering oil and looking for evidence of leaks.

a. Inspect the hydraulic pump. Look especially for signs of leaks at the pump mounting gasket and between the pump and its cover. Tighten the mounting and cover bolts if necessary.

(1) Examine all hydraulic hoses carefully, especially the high-pressure hoses between the pump and the control valve and between the control valve and power cylinder. The hoses should be secure in their clamps and not rubbing against other parts or components. Unless there is evidence of leaks, do not tighten any of the hose fittings.

(2) Check the control valve for evidence of leaks and for loose valve-to-steering jacket mounting bolts.

(3) Check the power cylinder for evidence of leaks around the fittings, hoses, and the cylinder-to-steering gear mounting bolts.

b. If no leaks are evident in the system, you can now add oil to the reservoir if you found the oil level low when you checked it. Of course, if you found the oil dirty or mixed with water, drain the old oil and refill it with clean oil. While the oil is draining, clean the filter screen. The oil used is OE (oil, engine) of the grade prescribed for the vehicle's engine. The oil level in the reservoir should be maintained at 3/4 full in order to allow for expansion.

c. Continue your inspection by checking the steering gear itself.

(1) Look for evidence of lubrication oil leaks around the gear housing gaskets and seals.

(2) Check the level of the lubrication oil in the steering gear housing by removing the filler plug in the top of the housing. If necessary, fill the housing with the proper grade of gear oil (GO). This oil is much heavier than the OE used in the hydraulic system. It is easy, therefore, to determine whether the hydraulic system or the steering gear is at fault if a leak is discovered around the steering gear housing.

(3) Check the steering gear-to-frame bracket mounting bolts with a wrench. Also check the steering column-to-dash panel bracket bolts for tightness.

d. Start the engine and check the hydraulic system for leaks while oil pressure is applied. Recall that high pressure is developed in the system only when a turning effort is applied on the steering wheel. So have a buddy turn the steering wheel while you look for oil leaks. Don't hold the steering against the steering stop for more than a few seconds at a time because this can damage the hydraulic system. It's true that the relief valve will open to prevent the pressure from going high enough to rupture lines and units; however, the high pressure creates heat which can damage the system if maximum pressure is maintained too long.

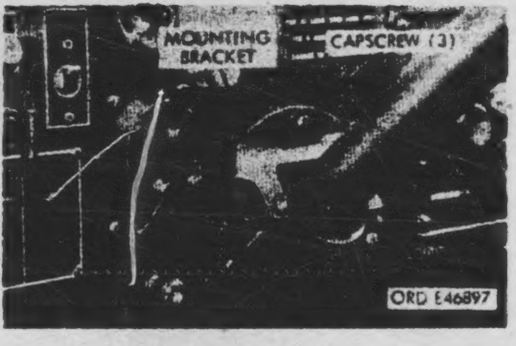
e. Road test the vehicle. Check for any tendency to wander, weave back and forth, or shimmy. Check for excessive free play, binding, and for pulling to the right or left. Also check the action of the steering assist through both right and left turns. The steering effort required should be so small that you can turn the steering wheel with your thumb and forefinger while the vehicle is moving.

14. ISOLATING FAULTS. If the road test reveals any steering faults, the next step is to find the cause. Common steering faults, their causes, and remedies were covered in anothe~~r lesson and~~, in general, will also apply to the power steering system of the 5-ton truck. Here we will only describe faults that are peculiar to the power steering system of the 5-ton truck.

a. If the steering was hard or was binding when turning, the trouble could be the power steering gear, steering column jacket linkage, or steering knuckle pivots. To pinpoint the trouble you will need to disconnect the steering linkage from the steering gear. This is done at the point where the upper drag link connects to the pitman arm.

(1) To disconnect the drag link from the pitman arm, remove the cotter pin and dust shield from the upper drag link end. Unscrew the drag link adjusting plug as far as possible without removing it. Turn the steering wheel back and forth to loosen the ball seats on the pitman arm ball stud. Then lift the drag link from the pitman arm ball stud.

(2) Use a jack and raise the front axle until both front wheels are off the ground. Grasp one front wheel at the front and rear and pivot the wheels back and forth on their steering knuckles. If the wheels pivot easily, any hard or binding steering is not caused by the steering knuckles or steering linkage.



(3) The binding problem may be caused by the steering column jacket being misalined with the steering gear. To check for this, loosen the mounting bracket capscrews and the clamp bolt securing the steering column jacket to the instrument panel. If the column is misalined enough to cause the steering shaft to bind, it will realine itself when the capscrews and clamp are loosened. Tighten the mounting screws and clamp; then turn the steering wheel to check for binding. If it still binds, the trouble is in the steering gear. If the problem was hard steering with no binding, the cause is in the hydraulic system.

b. If the vehicle pulled to the right or left during the road test, it could be caused by the same things that cause this on other vehicles, such as unequal tire pressure or dragging brakes. On the 5-ton truck, however, pulling to one side can also be caused by the hydraulic power steering. You can check for this in the following manner:

(1) The drag link must be disconnected from the pitman arm. Make sure that the steering gear is in the midposition. Do this by turning the steering wheel in one direction as far as it will go. Then, counting the number of turns, turn the wheel in the opposite direction as far as it will go. Turn the wheel back just half the number of turns you counted from stop to stop.

(2) Now start the engine and operate it at a fast idle. Without touching the steering wheel, watch it to see if it moves by itself. If it does, the power steering control valve is not centered; that is, it does not return to the neutral position. If this condition exists it can be caused by loose control valve mounting bolts or loose cam cover bolts at the ends of the cam. If tightening these bolts does not correct the problem, the cause is a defective control valve or the valve is not adjusted properly.

c. After the cause of trouble has been corrected you must reconnect the drag link to the pitman arm. If the repairs are beyond the organizational level of maintenance, notify your maintenance sergeant so that he can arrange for the truck to be repaired by your support unit. When connecting the drag link, make sure that the ball stud is properly positioned between the ball seats and tighten the drag link adjusting plug until it bottoms. Then back off the adjusting plug until its slot is alined with the first cotter pin hole. Install the dust shield and a new cotter pin; then lubricate the drag link.

d. In order to isolate the fault in the hydraulic system, the repairman from the support unit may use a pressure test gage set that is designed for this task. Just in case you get to assist on the job, here is how it is done.

(1) The high-pressure line between the pump and control valve is disconnected at the control valve. A tee fitting is installed on the control valve where the line was removed. Then the high-pressure line is connected to the tee fitting. At the center of the tee, connect the pressure gage using a short hose that is provided in the test kit. The hydraulic system can now be operated and the pressures developed will be shown on the pressure gage.

(2) Before making any pressure tests, fill the reservoir to the proper level with OE 10 engine oil and operate the engine until the hydraulic oil is at normal operating temperature. Should a rapid pressure buildup occur when the engine is started, turn the engine off quickly. Look for plugged lines, fittings, and oil passages before going any farther. A plugged or partially plugged passage blocking flow may cause pressure buildup that will burst lines or castings.

(3) After the unit has reached normal operating temperature, turn the steering wheel for a right turn with the engine running at 1,000 RPM. Continue turning the steering wheel until the right turn stop is reached; then hold it tight against the stop for just a few seconds. The gage should read 750 PSI for trucks with gasoline engines and between 850 and 1,000 PSI for multifuel and diesel engines.

(4) To repeat this test in the left turn position, it may be necessary to have an assistant hold a piece of iron, 1/4-inch thick, between the front axle left turn stop. If the hydraulic power piston is allowed to travel to the end of the cylinder on a left turn, it uncovers a port that allows the escape of pressure. The 1/4-inch piece of iron between the stop prevents the piston from traveling far enough to uncover the port.

(5) If the pressure is too low it will be necessary to make a further test to tell which unit is at fault if the relief valve and pump are separate assemblies. This is done by blocking the oil flow to the relief valve. Care must be used to prevent the pressure from building above 750 PSI when making the pressure test with the relief valve blocked. If this test raises the pressure, the relief valve is defective. If the pressure is still too low, the pump is probably defective. If replacing the pump does not raise the pressure, the trouble will be internal leakage in the control valve or power cylinder.

(6) If the pressure was too high with the relief valve connected properly in the system, the relief valve is at fault. On trucks with gasoline engines the relief valve is replaced separately, but the steering pump must be replaced on trucks with multifuel and Mack diesel engines.

SECTION III. CONCLUSION

15. SUMMARY.

a. Of the four basic types of hydraulic system diagrams, graphical diagrams are usually preferred for troubleshooting purposes. The graphical diagram is made up of simple symbols to show the function of the system components and the flow of liquid. The USASI symbol system, which is the latest in use, contains a minimum of printed words so that they bridge language barriers. If the mechanic does not have these symbols memorized he must have a complete listing of them on hand for reference to read the diagrams.

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b. Although hydraulic systems vary a great deal in design, improper operation of any system can generally be traced to one of a few common causes. The causes are wrong oil in the system, low oil level, defective parts, leaks, foreign substance in the system, improper adjustments, and improper operating procedures. In order to locate the cause of trouble and to repair the vehicle quickly, the mechanic may use a system that can be called STOP - S for study, T for test, O for organize, P for perform repairs.

c. As you can see from the procedures described in this lesson, removing and replacing some of the Ross HF-64 power steering system parts can be a big job. For this reason, be sure that you find the cause of a steering problem before you start replacing parts. A mechanic would feel very foolish if he replaced the steering gear and then found out that the cause of hard steering was a defective bearing in a steering knuckle. If you are in doubt as to what the exact cause is, consult an experienced repairman. He will be glad to assist.

16. PRACTICE TASKS. The appendix of this lesson contains a list of tasks associated with power steering gear maintenance. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist who is qualified in the MOS when you practice the tasks. Restudy the appropriate training material and practice the tasks until you become proficient in each one.

EXERCISE

66. What type of hydraulic system diagram should the mechanic use for locating the oil reservoir on a vehicle?

    a. Block
    b. Cutaway
    c. Pictorial

67. Why are graphical diagrams of hydraulic systems used?

    a. To give a complete listing of parts
    b. To show detailed construction of parts
    c. To identify the purpose of parts

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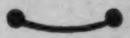
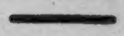
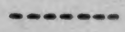
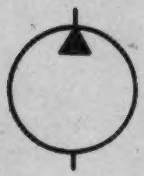
68. What hydraulic system part is often shown by symbols at several different points on a diagram even though the system contains only one of the parts?

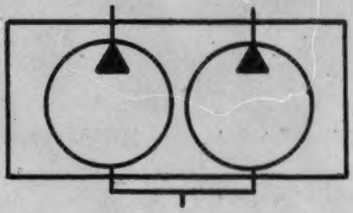
a. Pump
b. Reservoir
c. Valve

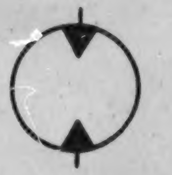
69. Which symbol shows a hydraulic drain line?

a. 
b. 
c. 

70. What symbol is used to show a reversible hydraulic motor?

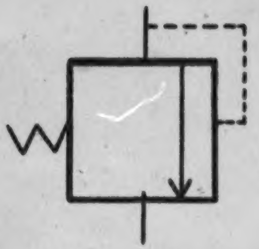
a. 

b. 

c. 

71. Which statement is true in regard to the accompanying symbol of a relief valve?

a. Spring pressure opens the valve
b. The valve is normally closed
c. Liquid flow is permitted in either direction



72. To which section of a steering control valve symbol are the connecting lines drawn?

a. Neutral
b. Right turn
c. Left turn

73. What is the first step in troubleshooting a hydraulic system?

a. Study
b. Test
c. Organize

74. How is high pressure created in the hydraulic power steering system to check it for leaks?

a. Run the vehicle at high speeds
b. Apply a turning effort on the steering wheel
c. Pressurize the oil reservoir with compressed air

75. On a 5-ton truck, the control valve for the steering system is

a. built into the hydraulic pump.
b. built into the hydraulic cylinder.
c. located on the upper end of the steering gear.

76. On what part of the 5-ton truck are the power steering pump and oil reservoir mounted?

a. Left fender well
b. Left front side of engine
c. Top of the power steering cylinder

77. How many V-belts are used to drive the power steering pump?

a. 1
b. 2
c. 3

78. How should the pitman arm on a 5-ton truck be positioned when it is installed?

a. Aline index marks
b. Downward
c. Forward

79. When removing the drag link, what action is taken with the dust shields after removal?

a. Discard
b. Clean and lubricate
c. Reverse front and rear shields

80. The pitman arm shaft end play is controlled by the adjusting

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a. nut.
b. shims.
c. plug.

81. During inspection of the power steering system of the 5-ton truck, what oil level should be indicated in the reservoir?

a. 1/2 full
b. 3/4 full
c. completely full

82. What should be checked if the steering gear on a 5-ton truck was hard or binding during turning?

a. Drag link adjustment
b. Front wheel alinement
c. Steering column jacket alinement

83. What would cause the power piston to move when the driver is not turning the steering wheel?

a. Oil pressure too high
b. Control valve not centered
c. Relief valve spring weak or broken

84. Why is a piece of iron held between the left steering stop when pressure testing the hydraulic steering of the 5-ton truck?

a. To keep the system from overheating due to excessive pressure buildup
b. To permit pressure buildup without opening the relief valve
c. To prevent oil from bypassing the power cylinder piston

85. What is required to isolate faults in the hydraulic system of the 5-ton truck power steering system?

a. Pressure test gage
b. External oil pressure
c. M3 oil pump and gage

APPENDIX

PRACTICE TASK LIST

Practice Objective . . . . After practicing the following tasks you will be able to:

1. Inspect the power steering system of a 5-ton truck.
2. Road test the vehicle to check the operation of the steering system.

Practice Tasks.

1. Troubles that can develop in power steering gears can be divided into two major groups: First, the troubles that originate in the mechanical steering gear itself, and second, the troubles that originate in the hydraulic system. Because the power steering gear is expensive and is difficult to replace, be sure that it can't be repaired on the vehicle before you condemn it. This means that the unit should be thoroughly inspected and all checks made before you decide it must be replaced.

a. Inspect the power steering gear on a 5-ton truck.

(1) Look especially for oil leaks around the reservoir, oil pump, relief valve, control valve, power cylinder, and all connecting hoses and fittings.

(2) Look for leaking seals and gaskets on the steering gear housing.

b. Check the following items on the power steering gear:

(1) Oil level and condition in the power steering reservoir. Add oil if necessary.

(2) Oil level in the steering gear housing.

(3) Using a wrench, check the steering gear mounting bolts and nuts as well as the nut that secures the pitman arm to the pitman arm shift lever.

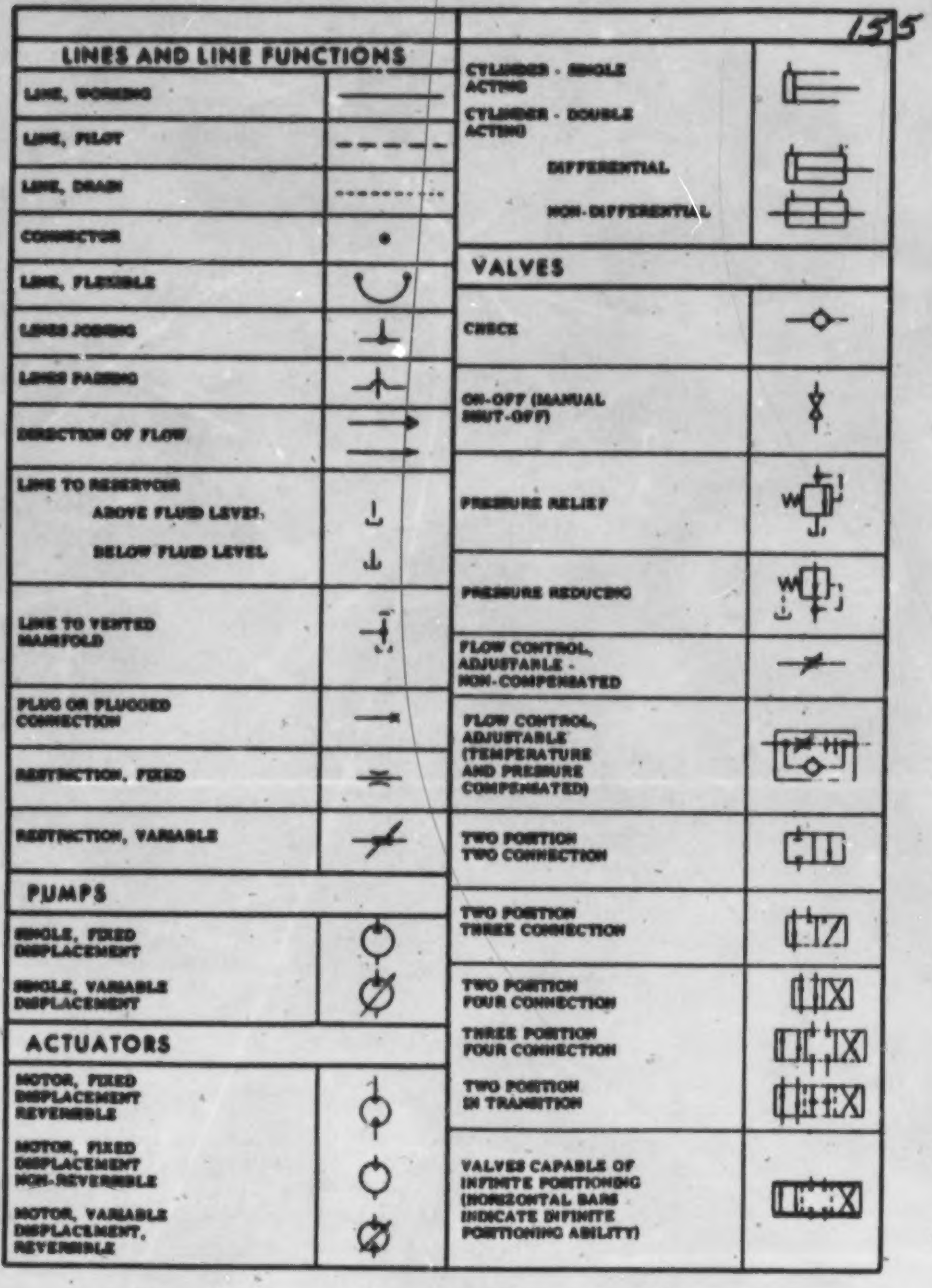
(4) With an assistant turning the steering wheel back and forth, check for looseness at the steering gear or at any point in the steering linkage. Also look for pressure leaks.

2. Road test the vehicle.

a. Check for any tendency of the vehicle to drift to one side of the road, wander, or shimmy.

b. Turn the steering wheel through its entire range and note any evidence of binding on the part of the steering gear or steering linkage.

c. After the road test, return the vehicle to the shop and recheck for oil leaks.



LINES AND LINE FUNCTIONS

- LINE, WORKING
- LINE, PILOT
- LINE, DRAIN
- CONNECTOR
- LINE, FLEXIBLE
- LINES JOINING
- LINES PASSING
- DIRECTION OF FLOW
- LINE TO RESERVOIR
  - ABOVE FLUID LEVEL
  - BELOW FLUID LEVEL
- LINE TO VENTED MANIFOLD
- PLUG OR PLUGGED CONNECTION
- RESTRICTION, FIXED
- RESTRICTION, VARIABLE

PUMPS

- SINGLE, FIXED DISPLACEMENT
- SINGLE, VARIABLE DISPLACEMENT

ACTUATORS

- MOTOR, FIXED DISPLACEMENT REVERSIBLE
- MOTOR, FIXED DISPLACEMENT NON-REVERSIBLE
- MOTOR, VARIABLE DISPLACEMENT, REVERSIBLE
- CYLINDER - SINGLE ACTING
- CYLINDER - DOUBLE ACTING
  - DIFFERENTIAL
  - NON-DIFFERENTIAL

VALVES

- CHECK
- ON-OFF (MANUAL SHUT-OFF)
- PRESSURE RELIEF
- PRESSURE REDUCING
- FLOW CONTROL, ADJUSTABLE - NON-COMPENSATED
- FLOW CONTROL, ADJUSTABLE (TEMPERATURE AND PRESSURE COMPENSATED)
- TWO POSITION TWO CONNECTION
- TWO POSITION THREE CONNECTION
- TWO POSITION FOUR CONNECTION
- THREE POSITION FOUR CONNECTION
- TWO POSITION IN TRANSITION
- VALVES CAPABLE OF INFINITE POSITIONING (HORIZONTAL BARS INDICATE INFINITE POSITIONING ABILITY)

Foldout illustration No 1. USASI Graphical Symbols.

METHODS OF OPERATION	
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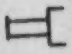
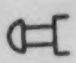
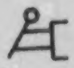
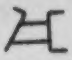
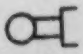
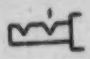
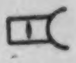
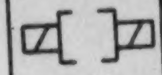
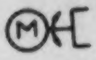
MANUAL	
PUSH BUTTON	
PUSH-PULL LEVER	
PEDAL OR TREADLE	
MECHANICAL	
DETENT	
PRESSURE COMPENSATED	
SOLENOID, SINGLE WINDING	
REVERSING MOTOR	
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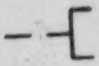
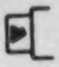
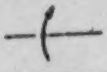
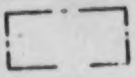
REMOTE SUPPLY	
INTERNAL SUPPLY	

MISCELLANEOUS	
ROTATING SHAFT	
ENCLOSURE	
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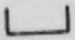
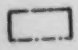
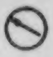
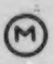
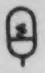
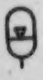
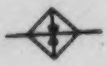
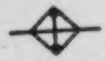
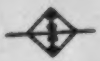
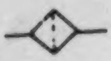
VENTED	
PRESSURIZED	
PRESSURE GAUGE	
ELECTRIC MOTOR	
ACCUMULATOR, SPRING LOADED	
ACCUMULATOR, GAS CHARGED	
HEATER	
COOLER	
TEMPERATURE CONTROLLER	
FILTER, STRAINER	

TABLE 1. IMPROPER OPERATION OF PUMPS.

FAILURE OF PUMP TO DELIVER FLUID

Possible Causes	Remedies
Low fluid level in reservoir.	Add recommended oil and check level on both sides of tank baffle to be certain pump suction is submerged.
Oil intake pipe or inlet filter plugged.	Clean filter or otherwise remove obstruction.
Air leak in inlet line preventing priming or causing noise and irregular action of control circuit.	Repair leaks.
Pump shaft turning too slowly to prime itself (vane type pumps only).	Check minimum speed recommendations in appropriate TM.
Oil viscosity too heavy to pick up prime.	Use lighter viscosity oil. Follow appropriate TM's recommendations for given temperature and service.
Wrong direction of shaft rotation.	Must be reversed immediately to prevent seizure and breakage of parts due to lack of oil.
Broken pump shaft or parts broken inside pump. Shear pin or shear linkage broken.	Refer to appropriate TM for replacement instructions.
Dirt in pump.	Dismantle and clean pump, and flush system.
On variable delivery pumps, the stroke is not right.	Check appropriate TM for instructions.

NO PRESSURE IN THE SYSTEM

Possible Causes	Remedies
Pump not delivering oil for any of the reasons given above in this table.	Follow remedies given above in this table.
Relief valve not functioning properly. (a) Valve setting not high enough. (b) Valve leaking. (c) Spring in relief valve broken.	Proceed as follows: (a) Increase pressure setting of valves (check TM for correct pressure). (b) Check seat for score mark and reseat. (c) Replace spring and readjust valve.
Vane or vanes stuck in rotor slots (vane type pumps only).	Inspect for wedged chips. Inspect oil for excessive viscosity.
Head loose (very infrequent).	Must not be tightened too tightly. See TM's instructions before tightening.
Free recirculation of oil to tank being allowed through system.	A return line may be open due to either a directional valve being set in the open-center neutral position or some other valve unintentionally open.
Internal leakage in control valves.	To determine location progressively, block off various parts of circuit. When trouble is located, repair.

Foldout illustration No 2 (page 1 of 2 pages).

TABLE 1. IMPROPER OPERATION OF PUMPS—CONTINUED.

PUMP MAKING NOISE

Possible Causes	Remedies
Partially clogged intake line, intake filter, or restricted intake pipe.	Clean out intake, strainer, or eliminate restrictions. Be sure inlet line is completely open.
Air leaks— (a) At pump intake piping joints. (b) At pump shaft packing (if present). (c) Air drawn in through inlet pipe openings.	Proceed as follows: (a) Test by pouring oil on joints while listening for change in sound of operation. Tighten as required. (b) Pour oil around shaft while listening for change in sound of operation. Follow appropriate TM's recommendations when changing packing. (c) Check to be certain inlet and return lines are well below oil level in reservoir. Add oil to reservoir, if necessary.
Air bubbles in intake oil.	Use hydraulic oil containing a foam depressant.
Reservoir air vent plugged.	Air must be allowed to breathe in the reservoir. Clean or replace breather.
Pump running too fast.	Check recommended maximum speeds from appropriate TM.
Too high oil viscosity.	Use lower viscosity oil. Follow appropriate TM's recommendations for given temperature and service.
Coupling misalinement.	Realine.
Pump head too loose, or a faulty head gasket.	Test by pouring oil over head. Replace gasket or tighten head, as necessary.
Stuck pump vane (vane type pump).	Inspect for wedged chips or sticky oil and reassemble.
Worn or broken parts.	Replace.

EXTERNAL OIL LEAKAGE AROUND PUMP

Possible Causes	Remedies
Shaft packing worn.	Replace.
Head of oil on inlet pipe connection.	Sometimes necessary, but will usually cause slight leakage. Keep all joints tight.
Damaged head packing.	Replace.

TABLE 1. IMPROPER OPERATION OF PUMPS—CONTINUED.

EXCESSIVE WEAR

Possible Causes	Remedies
Abrasive matter in the hydraulic oil being circulated through the pump.	Install adequate filter or replace oil more often.
Viscosity of oil too low for working conditions.	Check pump TM's recommendations or consult the lubrication chart.
Sustained high pressure above maximum pump rating.	Check relief or regulator valve maximum setting.
Drive misalinement or tight belt drive.	Check and correct.
Air recirculation causing chatter in system.	Remove air from system.

BREAKAGE OF PARTS INSIDE PUMP HOUSING

Possible Causes	Remedies
Excessive pressure above maximum pump rating.	Check relief or regulator valve maximum setting.
Seizure due to lack of oil.	Check reservoir level, oil filter, and possibility of restriction in inlet line.
Solid matter being wedged in pump.	Install filter in suction line.
Excessive tightening of head screws.	Follow pump appropriate TM's recommendations.

TABLE 2. IMPROPER OPERATION OF ACTUATING MECHANISMS.

SYSTEM INOPERATIVE

Possible Causes	Remedies
Any of the reasons listed in tables.	Follow remedies given in tables.

MECHANISMS CREEP WHEN STOPPED IN INTERMEDIATE POSITION

Possible Causes	Remedies
Internal leakage in actuating cylinders or operating valves.	Replace piston packing or replace cylinder if walls are scored. Replace or repair valve.

TABLE 2. IMPROPER OPERATION OF ACTUATING MECHANISMS—CONTINUED.

TIMES OF OPERATION LONGER THAN SPECIFIED

Possible Causes	Remedies
Air in system.	Bleed the system.
Internal leak in actuating cylinder or directional control valve.	Replace piston packing or replace cylinder if walls are scored. Replace or repair valve. Clean unit to remove foreign matter, then check cam clearance.
Worn pump.	Repair or replace.
If action is sluggish on starting up, but somewhat less sluggish after operating temperatures have increased, or if action slows down after warmup (depending on equipment and circuit design), it is probable that viscosity of oil is too high.	Check TM lubrication order.

EXTERNAL OIL LEAKAGE

Possible Causes	Remedies
End caps.	Tighten, if possible, or replace gasket.
Chevron seals.	Adjust or replace seal.

ABNORMAL PACKING GLAND WEAR

Possible Causes	Remedies
Cylinder not securely fastened to frame, causing vibration.	Tighten. This should be checked periodically.
Misalinement of cylinder and piston rod extension.	Check and correct.
Side load on piston rod.	Check for alinement of cylinder, worn pins or ball joints.

TABLE 3. IMPROPER OPERATION OF ACCUMULATOR.

PRESSURE FROM ACCUMULATOR DROPS SUDDENLY WHEN POSITION OF SELECTOR VALVE IS CHANGED

Possible Cause	Remedy
Internal or external leak in accumulator.	Repair leak or replace accumulator.

WHEN PUMP IS RUNNING PRESSURE IS NORMAL, BUT WHEN PUMP IS STOPPED NO PRESSURE IS AVAILABLE

Possible Cause	Remedy
Leaking gas valve or leaking check valve in hydraulic line.	Replace check valve or gas valve.

Foldout illustration No 2 - continued (page 2 of 2 pages).

TABLE 3. IMPROPER OPERATION OF ACCUMULATOR–CONTINUED.

SLUGGISH RESPONSE FROM ACCUMULATOR

Possible Causes	Remedies
Stoppage of oil screen in accumulator.	Dismantle accumulator and clean screen.
Gas precharge not sufficient.	Precharge according to appropriate TM's instructions; also check for gas leaks.

Note. Be sure all internal pressure is released before repairs are made on accumulators.

TABLE 4. EXCESSIVE HEATING OF OIL IN SYSTEM.

HEATING CAUSED BY POWER UNIT (RESERVOIR, PUMP, RELIEF VALVE, AND COOLERS).

Possible Causes	Remedies
Relief valve is set at a higher pressure than necessary. Excess oil dissipated through increased slippage in various parts, or through relief valve or through directional valve.	Reset relief valve, after checking TM for correct pressure.
Internal oil leakage due to wear in pump.	Repair or replace pump.
Viscosity of oil too high.	Check LO for correct oil viscosity grade to be used at various temperatures.
Pumps assembled after overhaul may be assembled too tightly. This reduces clearances and increases friction.	Follow TM when rebuilding a pump.
Leaking check valves or relief valves in pump.	Repair or replace.
Improper functioning of oil cooler, or coolant is cut off.	Inspect cooler and see that it is clean inside and outside and that air flow or coolant flow around fins is not cut off.

HEATING BECAUSE OF CONDITIONS IN SYSTEM

Possible Causes	Remedies
Restricted lines.	If lines are crimped, replace; if partially plugged for any reason, remove obstruction.
Large pump deliveries not unloaded properly.	Make certain that open-center valves are neutralized and that any pressure-relieving valves are in the correct position. Only small pump volumes should be allowed to remain at high pressures when running idle for long periods of time.
Insufficient radiation.	Use artificial cooling.
Internal leaks.	Locate leaks, then replace packing.

TABLE 4. EXCESSIVE HEATING OF OIL IN SYSTEM–CONTINUED.

HEATING BECAUSE OF CONDITIONS IN SYSTEM–CONTINUED.

Possible Causes	Remedies
Reservoir too small to provide adequate cooling.	Replace with larger reservoir, or install cooler.
Undersize valves or piping.	Check flow velocity through lines and valves and compare with TM's recommendations. If excessive, replace by installing larger equipment.

Note. If the system operates continually at high operating temperatures, consideration should be given to the installation of an oil cooler.

TABLE 5. IMPROPER OPERATION OF FLUID MOTORS.

MOTOR TURNING IN WRONG DIRECTION

Possible Cause	Remedy
Conductors crossed between control valve and motor.	Check circuit to determine correct conductor connection between control valve and motor.

MOTOR NOT TURNING OR NOT DEVELOPING PROPER SPEED OR TORQUE

Possible Causes	Remedies
System overload relief valve adjustment not set high enough.	Check system pressure and reset relief valve.
Relief valve sticking open.	Clean or replace relief valve and adjust.
Free recirculation of oil to reservoir being allowed through system.	Directional control valve may be in open center neutral (spool not shifting when control is operated); check control valve linkage.
Driven mechanism binding because of misalinement.	Check motor shaft for alinement.
Pump not delivering enough GPM or pressure.	Check pump GPM and pressure, repair or replace.
Motor yoke not set at proper angle (on adjustable motors).	Adjust pump yoke angle.

EXTERNAL OIL LEAKAGE FROM MOTOR

Possible Cause	Remedy
Seals leaking (may be due to drain not being connected from motor to tank).	Check motor for 3d line (this drain line must go to tank used on piston and vane motors).

Note. - See also table 1 on the improper operation of pumps.

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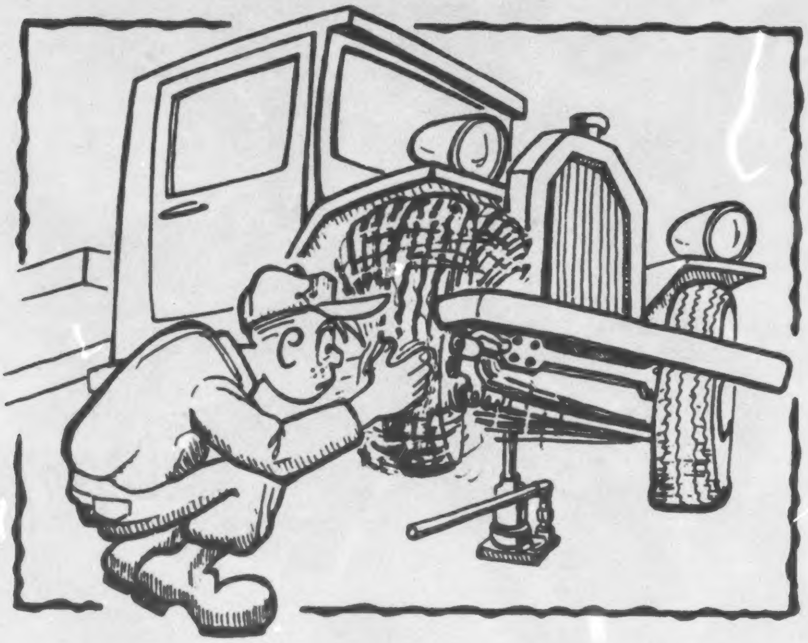
ENLISTED MOS

CORRESPONDENCE/OJT COURSE

ORDNANCE SUBCOURSE 63B207



LESSON 5

MAINTENANCE OF STEERING LINKAGES

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

LESSON ASSIGNMENT SHEET

Ordnance Subcourse No 63B207 . . .	Wheeled Vehicle Steering Systems
Lesson 5	Maintenance of Steering Linkages
Credit Hours	Three
Lesson Objective	After studying this lesson you will be able to: 1. Explain the procedures used for inspecting, testing, and adjusting the steering linkage components used on wheeled vehicles. 2. Determine the procedures to repair the steering linkage components. 3. Explain the procedures for replacing the parts of a wheeled vehicle steering system. 4. Explain the procedures used to adjust the toe-in of the front wheels of a wheeled vehicle. 5. Describe the procedures for troubleshooting the components of a steering system.

Text . . . . Attached Memorandum

Materials Required . . . . Answer sheet and response list

Suggestions . . . . Refer to the appropriate illustration when studying this lesson.

FOREWORD

In order to control the steering of a wheeled vehicle, the steering gear must be connected to the steering axle. The components that make up this connection are known as the steering linkage. The steering linkage is quite simple on vehicles such as the 2-1/2-ton truck with a conventional front axle. The steering linkage is a little more complex on vehicles such as the 1/4-ton truck with individual wheel suspension.

Some parts of the steering linkage require very precise adjustments because they control some of the factors affecting the alinement of the front wheels. Keeping such parts properly adjusted is one of the jobs done by a wheeled vehicle mechanic.

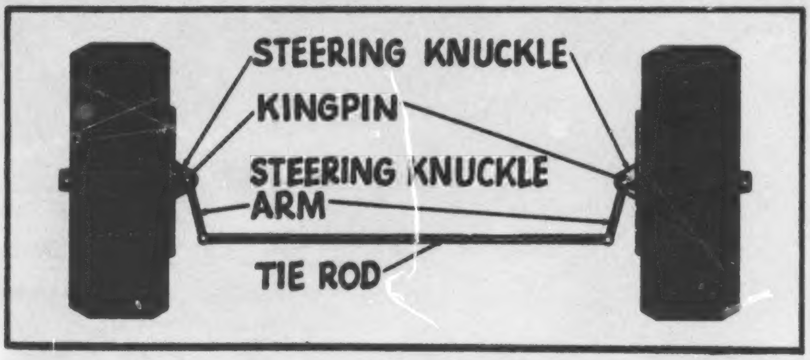
Above all, when inspecting the steering linkage, remember how important the linkage is to the safety of the driver and passengers of a vehicle. Loose arms or tie rod drag link ends could drop off and leave the driver with no steering control at all. A badly wrecked vehicle and seriously or fatally injured personnel could be the result of the loss of steering control.

ATTACHED MEMORANDUM

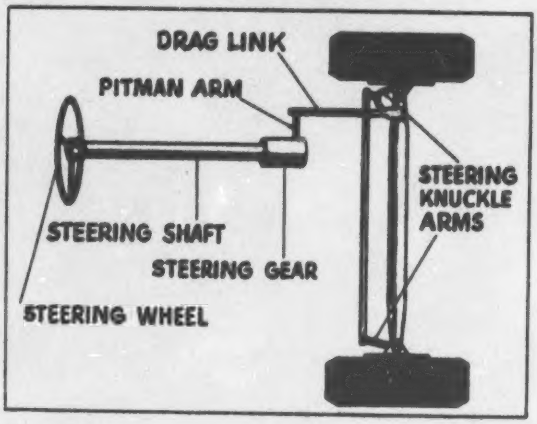
SECTION I. 1/4-TON TRUCKS

1. INTRODUCTION. The steering linkage on wheeled vehicles plays a very important part in the steering system. The linkage connects the steering gear, which is mounted solidly to the frame, to the steering axle, which is constantly moving up and down. Part of the linkage connects the two wheels to turn them in the direction desired by the operator. Not only does the steering linkage have to be very flexible, but it must also be exactly made. This is because it must hold the wheels in constant alinement at all times. The linkage must therefore be kept in proper adjustment to provide a safe steering and to prevent too much steering component and tire wear. Let's review some of the information you learned in earlier lessons about the construction and operation of this linkage. This will help you learn the information presented in this lesson on linkage maintenance.

a. Steering linkages are basically made up of arms, rods, and levers. The rods are often connected between the levers and arms. The joints where the arms, levers, and rods are connected are of the ball (socket) joint type. The rods between the front wheels are called tie rods. They tie the front wheels together. The ball joints that connect the tie rods to the wheel steering knuckle arms are called tie rod ends.



b. Some vehicles use a rod called a drag link. It usually connects the steering gear pitman arm to one front wheel. You can see an example of a drag link in the illustration. Notice that it connects the left front wheel to the pitman arm, which is mounted on the steering gear.



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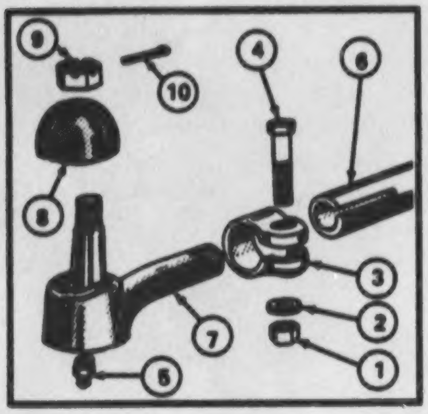
c. The ball joints used in steering linkages are of three general types:

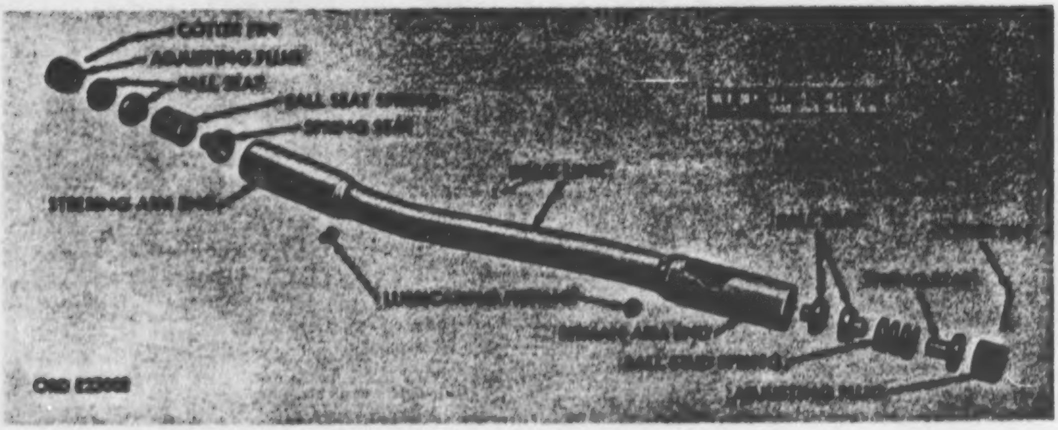

9
10
4
6
8
3
2
7
1
5

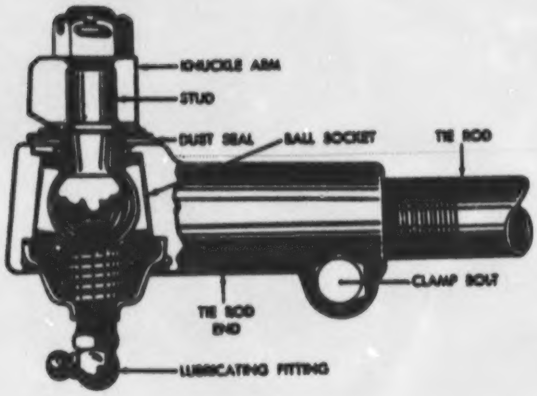
KEY

1. Nut
2. Lockwasher
3. Clamp
4. Bolt
5. Lubrication fitting
6. Adjustment sleeve (tie rod)
7. Tie rod end
8. Dust boot
9. Nut
10. Cotter pin

(1) One type is assembled and sealed at the factory and can only be lubricated or replaced in the field. Because it is not designed to be repaired or adjusted in the field, it is called the nonrepairable type.

(2) A second type can be adjusted in the field and, therefore, is called the adjustable type. This type ball joint is presently used on drag links of many vehicles.

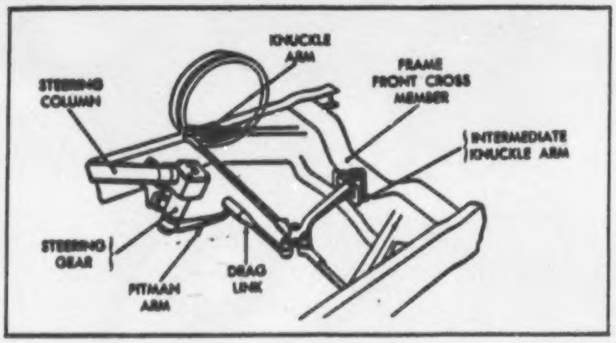

COTTER PIN
ADJUSTING PLUG
BALL SEAT
BALL SEAT SPRING
SPRING SEAT
STEERING ARM END
DRAG LINK
BALL SEAT SPRING
ADJUSTING PLUG


KNUCKLE ARM
STUD
DUST SEAL
BALL SOCKET
TIE ROD
CLAMP BOLT
TIE ROD END
LUBRICATING FITTING

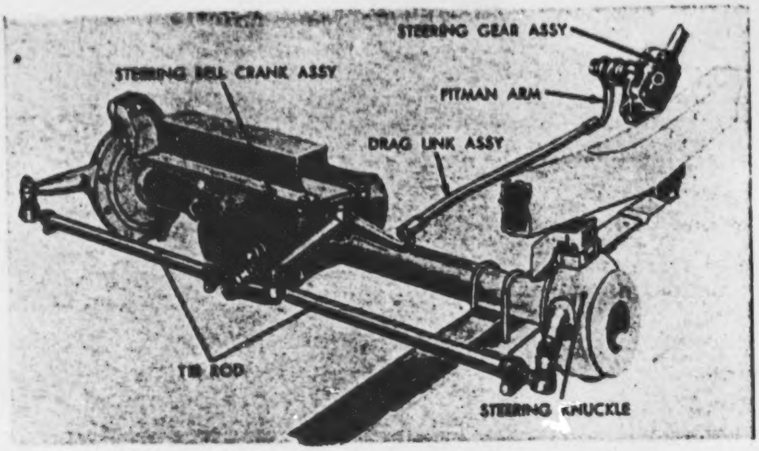
(3) The third type can be disassembled and repaired in the field. You will see all three types of steering ball joints as you study this lesson.

d. The drag links are normally a fixed length, whereas the tie rod length is normally adjustable. By changing the length of the tie rod, the toe-in of the wheels is changed. On some vehicles the tie rod is mounted behind the center of the wheels. On other vehicles the tie rod is mounted in front of the center of the wheels.

(1) Some vehicles use a two-piece tie rod. One tie rod connects the right wheel to a center-mounted steering arm or intermediate knuckle arm and is called the right tie rod. The other tie rod connects the left wheel to the center arm and is called the left tie rod. A drag link then connects the steering gear pitman arm to the center or intermediate knuckle arm. You can see an example of this type of two-piece tie rod linkage in the illustration.


KNUCKLE ARM
STEERING COLUMN
FRAME FRONT CROSS MEMBER
INTERMEDIATE KNUCKLE ARM
STEERING GEAR
PITMAN ARM
DRAG LINK

(2) Another version of the two-piece tie rod is used on some earlier 1/4-ton trucks. The tie rods connect the wheels to a bell crank. The bell crank is connected to the steering gear by a drag link and pitman arm on the steering gear. There are various other arrangements of steering linkage using two tie rods. You will see another one of these arrangements in paragraphs 2 through 4 below.



e. This review should have refreshed your memory of some of the steering linkage information you learned in earlier lessons. Now let's see how this linkage is maintained on specific vehicles. We will start with the inspection procedures for the 1/4-ton truck.

Note. - Refer to foldout No 1 in the back of this pamphlet while studying paragraphs 2 through 4 below.

2. INSPECTION. Before you start adjusting, repairing, or replacing parts, you should first inspect the overall condition of the steering system. Let's look over the steering linkage components on the 1/4-ton truck M151 and see what there is to inspect. On the 1/4-ton truck M151 the steering linkage consists of all the parts necessary to get steering effort from the steering sector shaft to the front wheels. The linkage includes the pitman arm (item H), pitman-to-idler arm rod assembly (item B), steering spindle arm tie rod assemblies (item J), steering idler arm and bracket (item A), and steering spindle arms (item K). The tie rod ends have factory assembled, nonadjustable type, spring-loaded ball sockets which compensate for wear of the ball studs. Grease fittings are located in each tie rod end and also with idler arm bushings.

a. One of the first steps in inspection is to look for bent, broken, or missing parts. The pitman-to-idler arm rod should be straight between the two points where the tie rods connect. The two tie rods normally have some bend in them. You can compare the tie rods to see if they both have the same general shape. Make sure you also check all parts to see that they are not cracked. This is especially true of the dust boots on the tie rod ends. Replace all missing parts.

b. While you are inspecting, make sure no parts are loose. Loose parts could be parts that are loose where they are mounted. Parts such as tie rod ends can also be loose in the ball socket if it is worn excessively. Another place you might find some looseness is in the adjustment threads in each tie rod sleeve or turn buckle. Be sure you check the pitman arm (item H) to see if it is loose on the pitman arm shaft. Now that we know some of the parts in the steering linkage can be loose, let's see how we find the looseness.

(1) One of the first ways to locate looseness is to try to move the steering linkage parts by hand. If you cannot find any looseness this way, try a second method. In this method you have an assistant "rock" the steering wheel back and forth while you look at all the steering linkage components. When using this method the vehicle should NOT be jacked up. The resistance of the tires on the floor or ground makes any looseness show up when the steering wheel is turned in each direction.

(2) Another method of finding looseness is to jack up one wheel at a time. Then have the assistant hold the steering wheel tight with the wheels straight ahead. Next, try to move the wheel to show up any looseness in the linkage. This means grasp the wheel in the front and the rear and try to move it like a shimmy action.

(3) If no looseness shows up during the above inspection, look at all of the retaining nuts. If you see what looks like rust around the part that binds against the metal, they are possibly loose. Tighten them up. If they won't tighten (too tight on the threads to be turned) you may have to split them with a chisel and replace them.

(4) If looseness does show up during the inspection, such as a loose tie rod end, you should replace the part after the inspection is finished. If a tie rod or tie rod end is replaced, the toe-in must be checked. (See paragraph 4 below.)

(5) A word of caution when a part is found loose due to loose nuts or bolts! Before you tighten the loose nuts or bolts, it is best to examine the condition of the loose parts and the retaining bolts and nuts. For example, let's say the vehicle was operated with the pitman arm loose on the

pitman arm shaft splines. This can wear the splines to a dangerous condition. If you just tighten up the retaining nut, the pitman arm could turn on the shaft sometime later due to the worn splines. Inspect the condition of the splines before you tighten the nut. If the splines are worn excessively in the pitman arm (item H), you, the wheeled vehicle mechanic, should replace the pitman arm. If the splines are worn on the pitman arm shaft, the steering gear assembly (item G) will have to be replaced. This is a job for support maintenance personnel.

(6) If during the inspection you find that the steering gear has excessive play, the steering gear must be adjusted or replaced. Notify your support maintenance unit if this condition exists. You are not authorized to perform this maintenance on this vehicle.

c. So far we have been concerned with bent, broken, missing, and loose steering linkage parts. Undoubtedly to us, any of these conditions creates a dangerous steering system. Now let's look at another condition that also makes a dangerous steering system - binding components or parts.

(1) Make sure that all parts function as they should. Turn the steering wheel from one end of its travel to the other end of its travel. There should be no binding. Jack up both front wheels and turn them in each direction (left and right). There should be no binding when this is done.

(2) If any binding is found in the steering system, you should find out just where the trouble is located. Section IV of this lesson covers various steering problems. You should gain some pointers on locating binding causes when you study this portion of the lesson.

d. When inspecting the steering linkage, don't forget to see if the parts are properly lubricated. It is best not to lubricate the steering parts (with the exception of the steering gear) until you check them for looseness. This is because the grease will temporarily tighten some loose parts. If the linkage needs lubricating (greasing), lubricate it according to the vehicle lubrication order (LO) AFTER you make your inspection. If parts are binding due to lack of lubrication, you should check the binding condition after you lubricate to make sure it has been corrected. Don't forget to check the steering gear oil level, however, when you inspect the vehicle.

3. COMPONENT REPAIR AND REPLACEMENT. So far we have learned how to inspect the condition of the 1/4-ton truck M151 steering linkage. Now, let's see how the parts are repaired or, if necessary, replaced.

a. First, let's decide when we should repair or replace. We normally think of the repair of a vehicle as inspecting, straightening, adjusting, and even replacing some parts. This means that if the vehicle has loose steering we may repair the steering by replacing the loose parts.

b. The next question is, "Should we repair or replace a specific steering component or part?" Let's say that during an inspection you find the right tie rod of the 1/4-ton truck is slightly bent. Should you straighten it or replace it? Straightening any steering linkage is at best a gamble! You might be able to straighten the bent right tie rod and safely reuse it. However, the tie rod could have cracked when it was bent, or it could crack when it is straightened. The crack could be inside so that it doesn't show. If you install this questionable tie rod you are gambling with human lives. This is a tactical vehicle and the steering must be able to take pretty rough treatment. Therefore, don't straighten the part. Replace it and you have repaired the steering linkage problem correctly.

c. This is not saying that no repairs should be made to the 1/4-ton truck M151 steering linkage. You may have some burred threads that can be straightened with a tap or die.

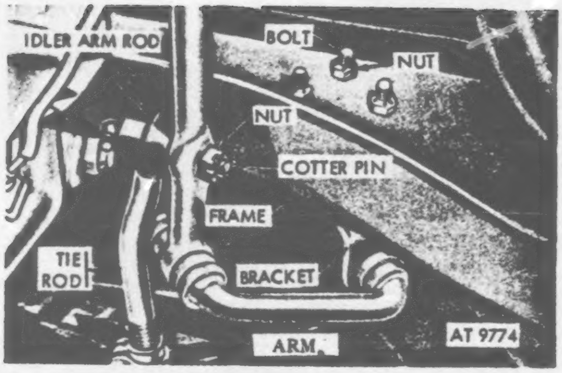
d. If during the inspection you find a tie rod end stud loose, disconnect the tie rod end. Look at the hole in which the stud is mounted. The hole is normally tapered and should be perfectly round. If the vehicle is operated for some time with the tie rod end ball stud loose, the hole may be worn oval or egg shaped. In this case the component with the oval hole must be replaced.

(1) If you look at the foldout in the back of the lesson, you can see that tie rod ends are used in many places. Every place that there is a tie rod end, there is a chance of a loose stud causing an oval hole.

(2) For example, the right tie rod outer end is connected to the right spindle arm. Should the tie rod end mounting hole in the spindle arm become worn oval, the spindle arm must be replaced. At the same time, the tie rod end will also probably have to be replaced due to the stud being worn.

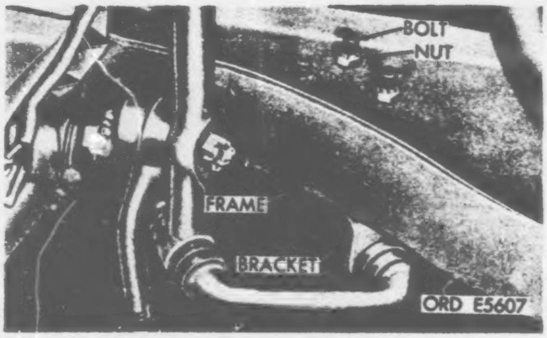
e. The pitman arm-to-idler arm rod is supported on the right-hand side by an idler arm and bracket (item A in the foldout). This is a critical wear point in the 1/4-ton truck steering gear. Let's take a close look at the idler arm assembly and see how it is repaired or replaced.

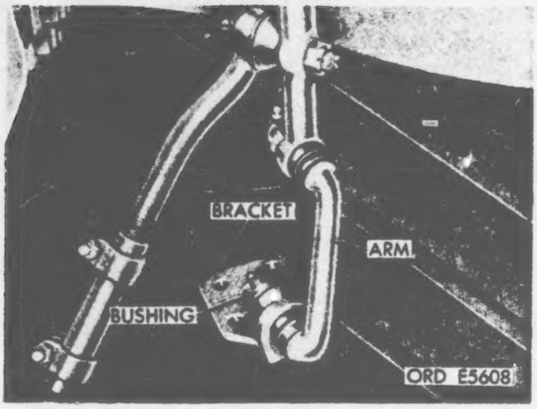
(1) The accompanying illustration shows the idler arm as it looks from underneath the vehicle. The idler arm is the U-shaped part located between its mounting bracket and the idler arm rod. The idler arm is threaded into a bushing on each end. The bushings are also threaded on the outside. The outside threads screw into the bracket on one end of the idler arm. The bushing on the other end of the idler arm threads into the pitman arm-to-idler arm rod (sometimes called the idler arm rod). Both bushings have grease fittings on the upper end and a grease seal on the lower end.



(2) Most of the wear on the idler arm occurs where the bushings are threaded on the idler arm. This is because the idler arm threads move in and out of the bushing threads as the steering wheel is turned. There should be no wear between the outer bushing threads and the bracket or idler arm rod. The bushings are tightened until they bottom in these two components. If the bushings do come in the bracket and idler arm rod it's a good possibility the holes are worn oval-shaped. This means all worn parts must be replaced.

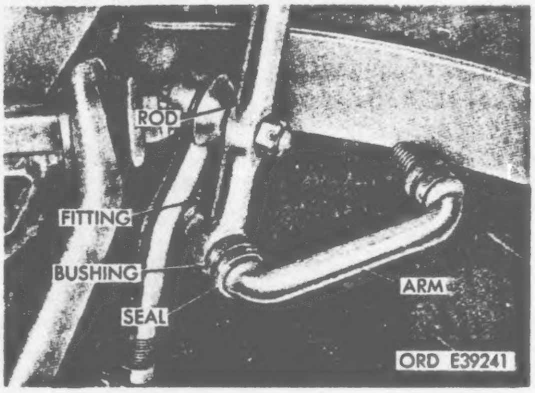
f. Let's say that during an inspection of the steering linkage you find excessive play in the idler arm at the bracket. You check the bushings and find they are tight both in the idler arm rod and in the bracket. The next question is how to replace the worn parts.





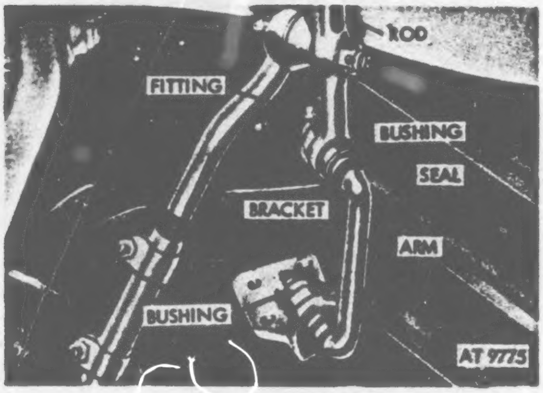
(1) The idler comes as part of a kit. The kit also includes both bushings, seals, and grease fittings. This means both bushings must be removed. It's a good idea to break the bushings loose with a wrench while they are still supported. Then remove the bracket from the frame and lower the idler arm as far as possible.

(2) Next, turn the bracket and bushing clockwise off the idler arm. This shows the idler arm has left-hand threads. Then turn the idler arm clockwise and screw it out of the other bushing. This end also has left-hand threads.



(3) Next, you should remove the bushings from the bracket and idler arm rod. You will probably have to mount the bracket in a vise to remove the bushing. Once you have removed the bushings, clean the threads in the idler arm rod and the bracket. Inspect the condition of the threads. If the threads are stripped or have been cross-threaded, replace the part. If the threads are serviceable you are ready to install the new bushings.

(4) First, lubricate all parts with GAA. Next, install the two replacement bushings. Then slide the neoprene grease seals over the idler arm threads until the seals bottom on the flange. Next, screw the idler arm into the idler arm rod bushing (counterclockwise) until it bottoms (becomes tight). Then back the idler arm up (clockwise) 1 to 1-1/2 turns. This allows the idler arm to swing back and forth as the steering wheel is turned.


ROD
FITTING
BUSHING
SEAL
BRACKET
ARM
BUSHING
AT 9775

176

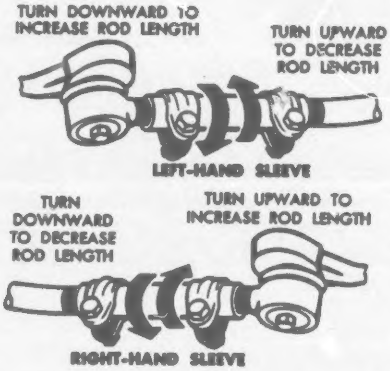
(5) Next, install the bracket and bushing on the other end of the idler arm. Make sure you first bottom the bushing on the idler arm and then back off 1 to 1-1/2 turns. Then bolt the bracket to the frame. Next, you should see if you can tighten the bushings any more. Then install the grease fittings and lubricate the idler arm with a GAA-filled grease gun.

(6) Now that you have finished installing the idler arm, you still have one more task to do. You should check the toe-in of the wheels. If the toe-in was set with the loose idler arm, it will probably be wrong now. Toe-in adjustment procedures are covered in paragraph 4 of this lesson.

g. Another linkage component you may have to replace is a tie rod end. On the 1/4-ton truck M151, one worn tie rod end may be cause for an entire steering link to be replaced. Let's see how this is possible.

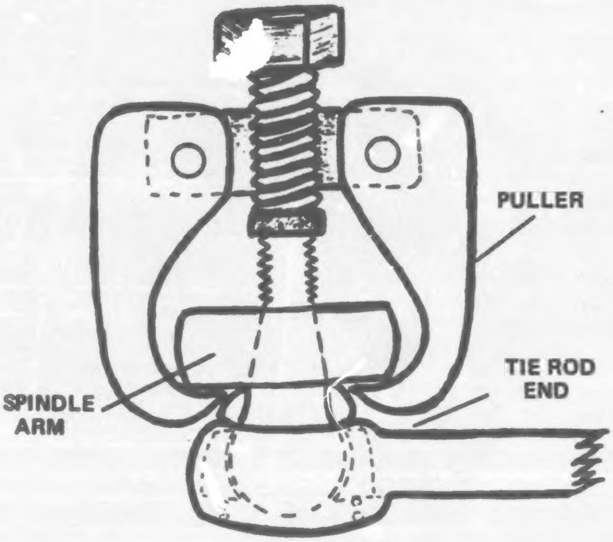
(1) Let's look at the foldout of the 1/4-ton truck linkage once more. We can see that the steering linkage between the two front wheels consists of three major links. These links are the left and right tie rods (called spindle arm tie rods (J) in the illustration) and the pitman arm-to-idler arm rod (B). Notice that the center link or pitman arm-to-idler arm rod is all one piece. It serves as mounting points for the idler arm and two tie rods. If its one tie rod end (ball joint) is worn, the entire rod must therefore be replaced.

(2) The left and right tie rods are actually made up of two tie rod ends and a sleeve. The tie rod ends thread into the sleeve. One tie rod end has left-hand threads and one has right-hand threads. If the sleeve is turned in one direction, the tie rod assembly gets longer. When the sleeve is turned in the other direction, the tie rod assembly gets shorter. This feature is used to adjust the toe-in of the front wheels, as you will see in paragraph 4 of this lesson. Each sleeve also includes two clamps. They are used to lock the sleeve threads to the tie rod end threads once the adjustment is completed.


TURN DOWNWARD TO INCREASE ROD LENGTH
TURN UPWARD TO DECREASE ROD LENGTH
LEFT-HAND SLEEVE
TURN DOWNWARD TO DECREASE ROD LENGTH
TURN UPWARD TO INCREASE ROD LENGTH
RIGHT-HAND SLEEVE

(3) The tie rod end stud is tapered or smaller on the outer end. It fits into a tapered hole. The stud is held in place with a retaining nut. When the nut is tight the tapered stud is wedged very tightly in the tapered hole. In fact, it is so tight that when the retaining nut is removed the stud is sometimes hard to remove from the tapered hole.

(4) There are various methods used to loosen the tapered tie rod end stud. These methods sometimes are different for each vehicle. One approved method for the 1/4-ton truck M151 is to first remove the retaining nut. Then hook a puller over the part with the tapered hole. Turn the puller screw against the stud and push the stud out of the hole. Then you are ready to remove the tie rod end from the sleeve.

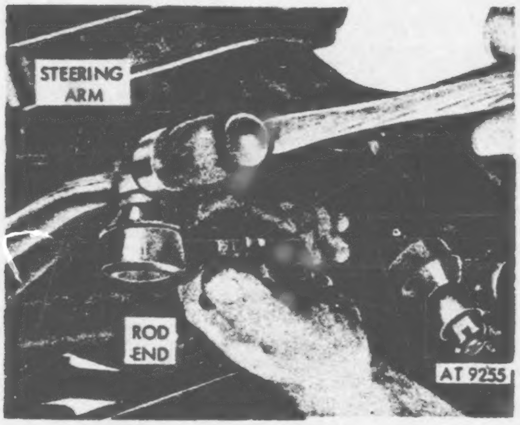


(5) To remove the tie rod end from the sleeve, you must first loosen the two clamps. Then hold the sleeve to keep it from turning and screw out the tie rod end.

(6) When installing the replacement tie rod end, it is important that it is screwed into the sleeve the right amount. It should be screwed in the same distance that the tie rod end on the other end of the sleeve is screwed in. Then, when the sleeve is turned to adjust the toe-in (see paragraph 4 below), both tie rod ends will have the same amount of thread contact in the sleeve. Otherwise, one tie rod end may be screwed almost out of the sleeve. You can look through the slot in the sleeve to determine the distance each tie rod end is screwed in.

(7) Screw in the tie rod end as explained above. Next, install the tie rod end stud into the tapered hole and install and tighten the retaining nut. Then install a cotter pin through the stud and nut to make sure the nut does not work loose.

(8) Once this is done, tighten the sleeve clamp bolts for the time being; then check the toe-in and make adjustments, if needed, as outlined in paragraph 4 below.



h. The 1/4-ton truck M151 has many tie rod ends that can give trouble. They can all be removed using the above puller method. If this type puller is not available, you can possibly loosen the stud by striking the part with the tapered hole with a hammer. This method works well with steering arms that are rigidly mounted. Do not hammer on the tie rod end itself or you will damage it. A third tie rod end removal method uses a wedge-type puller. The wedge is driven between the tie rod end and the part with the tapered hole, such as the spindle arm. This tool is often called a tie rod knocker. The wedge action pulls the tapered stud out of the tapered hole; however, the tool generally damages the dust seal. The best method to remove the tie rod end is therefore the first method, providing that the puller is available.

4. FRONT-WHEEL ALINEMENT. Many adjustments are possible on the front wheels and axle of the 1/4-ton truck M151. The wheels can be tipped in and out at the bottom for a camber adjustment. They can be tipped forward or backward for a caster adjustment. They can also be removed in or out in the rear of the wheels for a toe-in adjustment. Most of these adjustments are made at support maintenance. Only the toe-in adjustment is made at organizational maintenance. During this lesson we will learn how to adjust the toe-in. We will also learn where the caster and camber adjustments are located. Let's start with the toe-in adjustment.

a. Before the front wheel toe-in is checked (measured), you should check the condition of some of the components. Let's see what components should be checked.

(1) For example, the toe-in gage will give an incorrect reading if a wheel is bent, so check both front wheels. Jack the wheel up and turn it to see if it is straight.

(2) While you have the wheel jacked up, check the wheel bearings to make sure they are not loose. This can cause the toe-in to vary or change as the vehicle travels along.

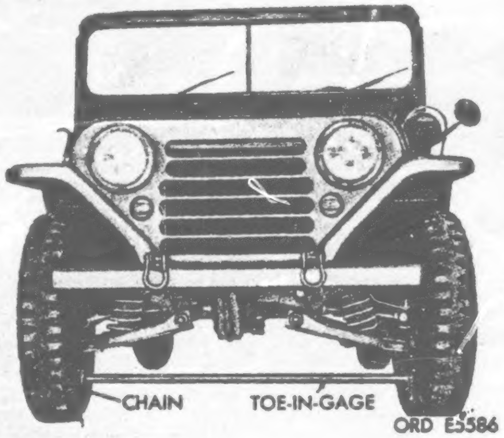
(3) Also, while you have the wheels jacked up, inspect the condition of the steering linkage as covered in paragraph 2 above. Replace any loose linkage parts that are worn excessively as covered in paragraph 3 above.

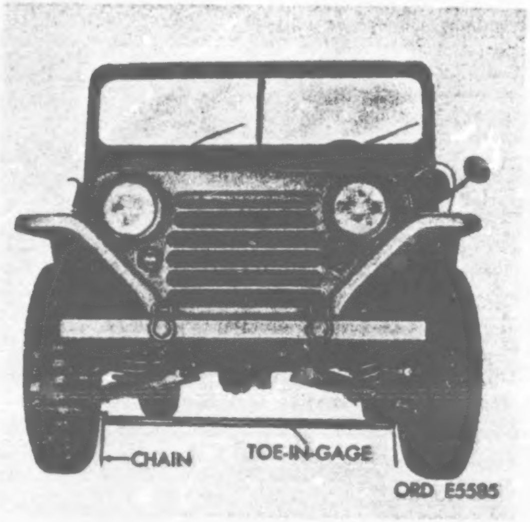
(4) Check the tire pressure in both front tires. The toe-in gage will not work properly with a half-flat tire.

(5) Look for any loose parts in the front suspension. If any looseness is found, the toe-in can be checked and adjusted if necessary. However, the caster and camber should also be checked by support maintenance personnel.

b. Once you are sure the front suspension, wheels, and steering linkage are serviceable, you are ready to check the toe-in. It should be done in the following manner:

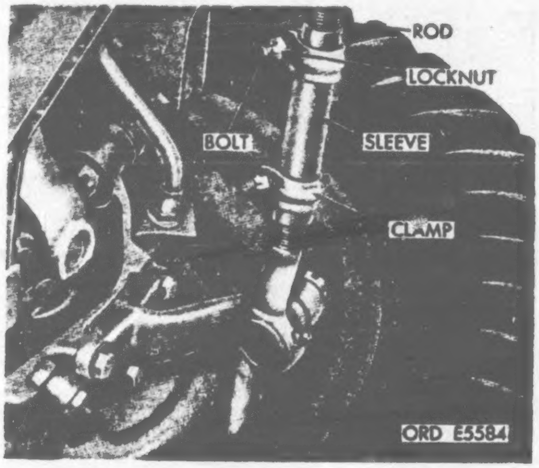
(1) Position the vehicle on smooth, level ground with the front wheels pointing straight ahead. Then install the toe-in gage between the front tires and ahead of the center of the wheels. Move the gage on the tires until the chains just touch the ground, as shown in the accompanying illustration. Then slide the gage pointer to zero.





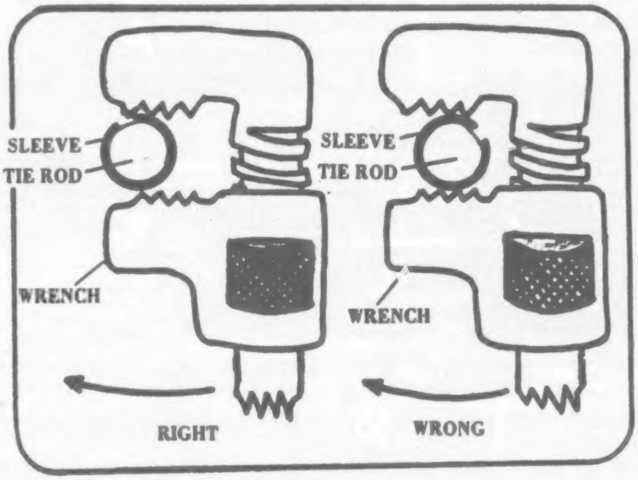
(2) Next, carefully move the vehicle ahead slowly until the gage is behind the axle and the chains again just touch the ground. The pointer on the gage will then indicate the amount of toe-in of the front wheels. The correct toe-in measurement for the 1/4-ton truck M151 should be from 1/32 to 5/32 inch. If the measurement does not fall in this range, the tie rods must be adjusted.

(3) Let's say when the toe-in was measured it was found to be 1/2 inch or too much toe-in. To correct the toe-in, both tie rods must be shortened. This will pull the rear of the front wheels closer together and make the toe-in less. One tie rod can be shortened and do the same job. However, the high point in the steering may be in the wrong place when you finish. You will see how this is true later in the lesson.



(4) Here is how you shorten or lengthen the tie rods. You must first loosen the clamp bolts and nuts on the adjusting sleeves. Then you must turn the sleeves. You must remember that each sleeve has left-hand threads in one end and right-hand threads in the other end. If it is turned in one direction the threads will pull the tie rod ends closer together. If it is turned in the other direction the threads will push the tie rod ends farther apart. The sleeve and tie rod ends therefore act like a turn buckle.

(5) There is a trick in turning the sleeve. The sleeve is split from one end to the other end. If a pipe wrench or channel-lock pliers are used, they must be positioned on the sleeve properly. The tool should be hooked on the sleeve so that it opens the split or gap. This will make the sleeve turn easily. Notice in the accompanying illustration that the wrench can also be positioned on the sleeve wrong so that it closes the gap. The sleeve will then be tightened as you try to turn the sleeve.



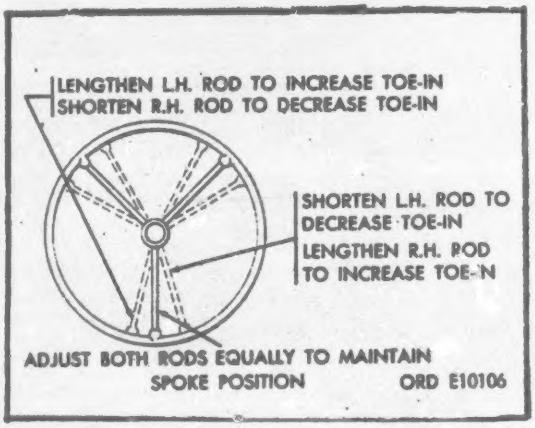
(6) To adjust the toe-in, turn the sleeve on each tie rod an equal amount. Then measure the toe-in again. If it is not between 1/32 and 5/32 inch, change each sleeve an equal amount and recheck the toe in. Do not forget to zero the gage each time it is moved to the front of the wheels. Once the toe-in is correct, tighten the clamp bolts on each sleeve.

c. The tie rod adjusting sleeves are also used to center the steering. When this adjustment is made, both sleeves are again turned an equal amount; however, they are turned in opposite directions. Let's go over this adjustment and see how it's done.

(1) Drive the vehicle straight ahead and notice the position of the steering wheel spokes. One spoke should be pointed down. If not, the tie rods must be adjusted.

(2) Make sure you turn each tie rod an equal amount. If you do not turn them equally, you will change the toe-in of the front wheels.

(3) Let's say when you road tested the vehicle, the lower spoke of the steering wheel was not straight down. It was a little to the right. Notice in the illustration the instructions on how to correct this problem. You must shorten the left-hand (LH) tie rod and lengthen the right-hand (RH) tie rod. If the spoke is to the left of straight down, you must lengthen the left-hand tie rod and shorten the right-hand tie rod.


LENGTHEN L.H. ROD TO INCREASE TOE-IN
SHORTEN R.H. ROD TO DECREASE TOE-IN
SHORTEN L.H. ROD TO DECREASE TOE-IN
LENGTHEN R.H. ROD TO INCREASE TOE-IN
ADJUST BOTH RODS EQUALLY TO MAINTAIN SPOKE POSITION
ORD E10106

(4) It is important that the steering spoke points straight down. Otherwise, the steering worm and roller will not be on the high point when the front wheels are pointing straight ahead. This would allow too much slack or play in the steering system.

d. As indicated earlier in the lesson, caster and camber adjustments are made at support maintenance. Just in case you might sometime be working at this level, we will cover the adjustment locations.

(1) The front-wheel caster is changed by tilting the lower part of the front suspension. If more negative caster is needed, the bottom of the wheel is tilted to the rear. If more positive caster is needed, the bottom of the wheel is tilted forward.

(2) Caster is changed by increasing or decreasing a shim pack thickness. The shim packs are used at two main points on each side of the vehicle. The shims are located between the lower suspension arm inner shaft and the front crossmember. Notice in the accompanying illustration that there are three shim packs. There are two shim packs at one point and one shim pack at the other point. The two-shim pack point is toward the front of the vehicle (above the repairman's hand). To change the caster, increase the shims at one point; then decrease the shims at the other point the same amount.

(3) Camber is adjusted using the same shims. If more positive camber is needed, equal amount of shims is added at each point. If more negative camber is needed, equal amount of shims is removed at each point. By changing an equal amount of shims, the caster will not be changed.

(4) When the caster or camber of the front axle is changed, the toe-in will also be changed. This means the toe-in will have to be checked and probably adjusted after adjusting the caster and camber.

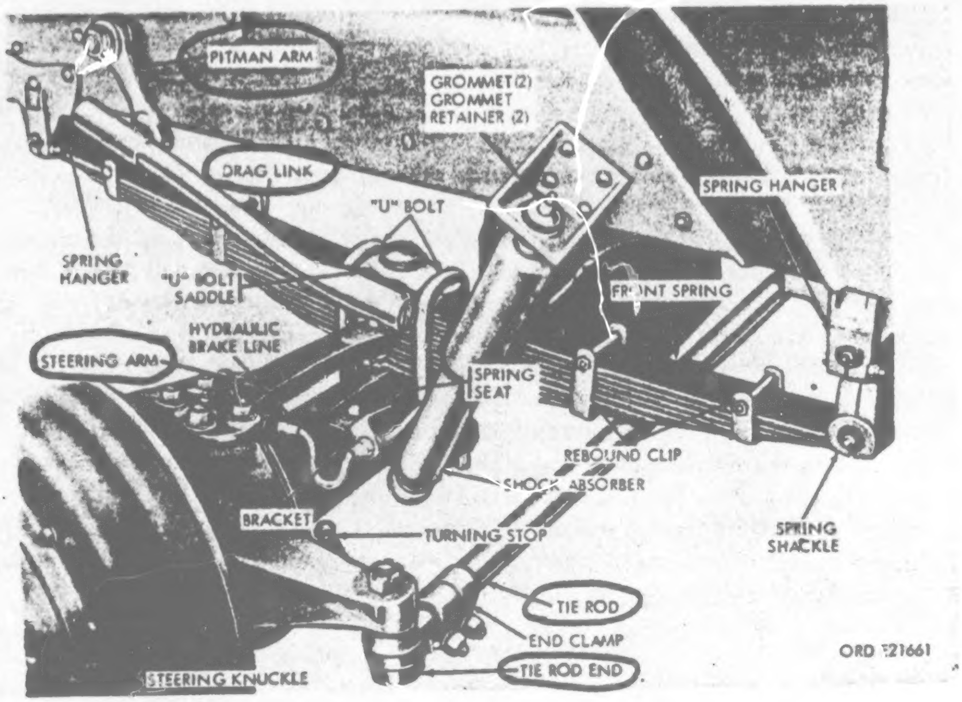
(5) The location and purpose of the caster-camber adjusting shims have been explained above. This is only part of the information covering caster and camber adjustments. Should you eventually be assigned at support maintenance, you must learn more about these adjustments. However, the information in this lesson should help you when you get to support maintenance.

e. This pretty well covers the 1/4-ton truck M151 steering linkage maintenance. Now let's see what should be done on the 2-1/2-ton truck steering linkage.

SECTION II. 2-1/2-TON TRUCK

5. INSPECTION. Like the 1/4-ton truck, inspection is also very important on the 2-1/2-ton truck. The steering linkage is not the same on the two vehicles. Therefore, let's see what makes up the 2-1/2-ton truck steering linkage such as used on the M35A2 cargo truck.

a. Starting at the steering gear, the linkage consists of the pitman arm, a drag link, one tie rod, and one steering arm. This steering arm is actually part of the front axle. The tie rod connects to the front axle at the steering knuckle. Let's take these parts one by one and see how they should be inspected.


PITMAN ARM
GROMMET (2)
GROMMET RETAINER (2)
DRAG LINK
"U" BOLT
SPRING HANGER
SPRING HANGER
"U" BOLT SADDLE
FRONT SPRING
HYDRAULIC BRAKE LINE
STEERING ARM
SPRING SEAT
REBOUND CLIP
SHOCK ABSORBER
BRACKET
TURNING STOP
SPRING SHACKLE
TIE ROD
END CLAMP
TIE ROD END
STEERING KNUCKLE

ORD E21661

(1) The pitman arm is similar to the M151 (1/4-ton truck) pitman arm. Inspection procedures are the same. Look for cracks in the metal. Make sure it is tight on the pitman arm shaft. While you are this close to the steering gear, make sure the steering gear mounting bolts are tight.

(2) Once you are sure the pitman arm is serviceable, inspect the condition of the drag link. Have some one "rock" the steering wheel with the front wheels on the ground. There should be very little, if any, movement in the ball sockets at either the pitman arm or the steering arm. If you see any movement at the ball sockets, the best thing to do is check the adjustments. Adjustment of the drag link is covered in paragraph 6 of this lesson. Make sure the drag link has cotter pins in both ends. The cotter pins prevent the adjustment plugs from turning.

(3) The drag link connects the pitman arm to a steering arm. The steering arm is part of the left steering knuckle of the front axle. The ball joint that connects the drag link to the steering arm should be inspected. Its tapered stud is held in the steering arm by a nut which can work loose. You should also inspect the steering arm where it mounts on the steering knuckle. It is secured to the steering knuckle with four studs and nuts. Make sure these nuts are tight. A word of caution! If the nuts are found loose, jack up both front wheels after the nuts are tightened. Then turn the steering knuckle back and forth to make sure it turns without a bind. If the steering knuckle turns with a bind, notify your support maintenance unit.

(4) The front wheels are tied together with one tie rod. The tie rod is connected to each steering knuckle by a tie rod end. Make a thorough inspection of the tie rod. Make sure it is not bent. Inspect the tie rod ends for looseness in the ball sockets. Use the same procedures used for the 1/4-ton truck to check for looseness. Make sure the tie rod ends are tight where they mount in the steering knuckles. Make sure both cotter pins are in place in the tie rod retaining nuts. Check the clamps on each end of the tie rod adjustable sleeve. Make sure the bolts are tight. Above all, make sure there are no cracks or breaks in the metal parts. Check the dust seals on each tie rod and make sure they are not cracked or missing. Replace any missing parts. If the adjustable sleeve is found loose, the toe-in must be checked as outlined in paragraph 7 below.

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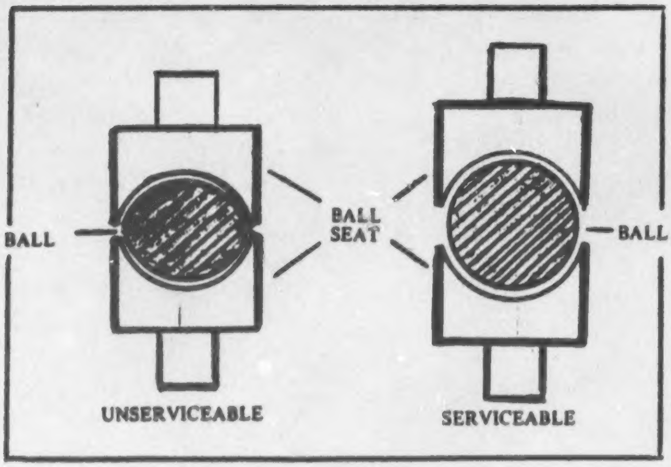
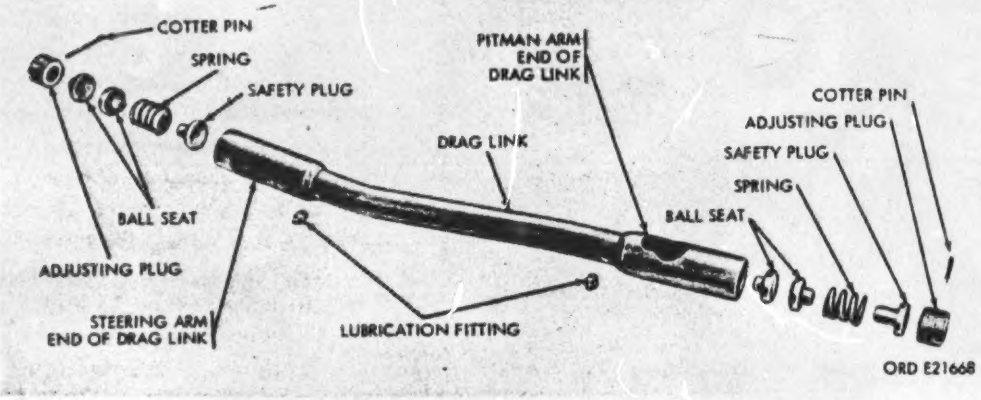


b. If all parts look operational, turn the steering wheel over its entire travel to check for binding. If the drag link was adjusted during inspection procedures, this check can be very important. If the steering turns easily in the center but binds on each side of the center, you may have to replace some parts. This binding after drag link adjustment indicates worn parts in the ball socket. If you look at the accompanying illustration you will see two drawings of ball sockets (drag link joints). Notice that the serviceable one has a round ball. The round ball can turn easily between the ball seats when the steering wheel is turned. The ball in the unserviceable joint is worn excessively. It is not round. Once the drag link is adjusted, the ball and seats will be too tight when the steering wheel is turned away from its center position. The only cure for this problem is to replace some parts. Let's find out what parts are replaced and how it's done. We will cover the entire steering linkage.

6. COMPONENT REPAIR AND REPLACEMENT. Once you learn how to repair the 1/4-ton truck steering linkage, you should have little trouble with the 2-1/2-ton truck. The steering linkage on the 2-1/2-ton M34- and M35-series trucks has less parts. There are only two tie rod ends, whereas the 1/4-ton truck has five. The 2-1/2-ton does have the two adjustable drag link joints as indicated in the above paragraph. Let's start with these joints and see first how they are adjusted.

a. It is important that the drag link joints are adjusted when the wheels are pointing straight ahead. This is where most of the wear will take place. Make sure the joints are lubricated before the adjustment is made. Then follow these steps to make the adjustment.

(1) Remove the cotter pin in one end of the drag link. Then turn the adjusting plug to the right (clockwise) until the plug bottoms. This means until the plug stops turning in. Do not try to force the plug to make it tighter.


COTTER PIN
SPRING
SAFETY PLUG
BALL SEAT
ADJUSTING PLUG
STEERING ARM END OF DRAG LINK
LUBRICATION FITTING
DRAG LINK
PITMAN ARM END OF DRAG LINK
COTTER PIN
ADJUSTING PLUG
SAFETY PLUG
SPRING
BALL SEAT
ORD E21668

(2) Once the plug bottoms, turn it back until the first or second cotter pin hole in the tube alines with the slot in the plug. Do not turn back more than 1/2 turn; then install a new cotter pin. This adjusts the ball socket spring tension.

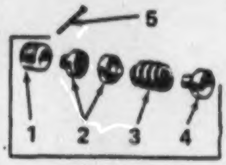
(3) Do not adjust the ball joint on the other end of the drag link yet. Jack up both front wheels so that there is no friction between the tires and the ground. Then turn the steering wheel to make sure there is no bind on either side of the center point due to a worn flat ball. This was covered in paragraph 5 above.

(4) If there is no bind on either side of the high point, adjust the ball joint on the other end of the drag link. Use the same method used on the first joint. Once the adjustment is made, turn the steering wheel and check again for a bind. If there is no bind the drag link is adjusted and serviceable.

b. Let's say once you adjusted the drag link ball socket spring tension, the steering was tight on each side of the center of its travel. You disassembled the joint on one end and found the ball flat on each side next to the ball seats. What should be repaired or replaced?

(1) None of the parts should be repaired; however, some should be replaced. Which parts are replaced depends on which end of the drag link the flat ball is found.

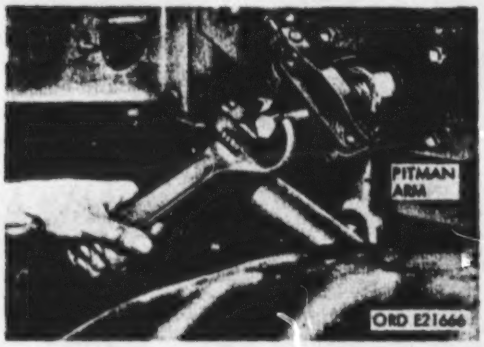
(2) If the flat ball is found at the forward ball socket, the pitman arm must be replaced. If the flat ball is found at the rear ball socket, the ball and stud must be replaced. The ball and stud at the rear of the drag link can be removed from the steering arm. Therefore, the steering arm does not have to be replaced due to the worn ball stud. Regardless of which ball is worn, the ball seats in the same ball socket should also be replaced. They are part of a kit. The kit includes all the inside parts of each end of the drag link as shown in the accompanying illustration.



1–Adjusting plug
2–Ball seat
3–Spring
4–Safety plug
5–Cotter pin

(3) Make sure that when you install the drag link parts you lubricate them with GAA (grease, automotive and artillery).

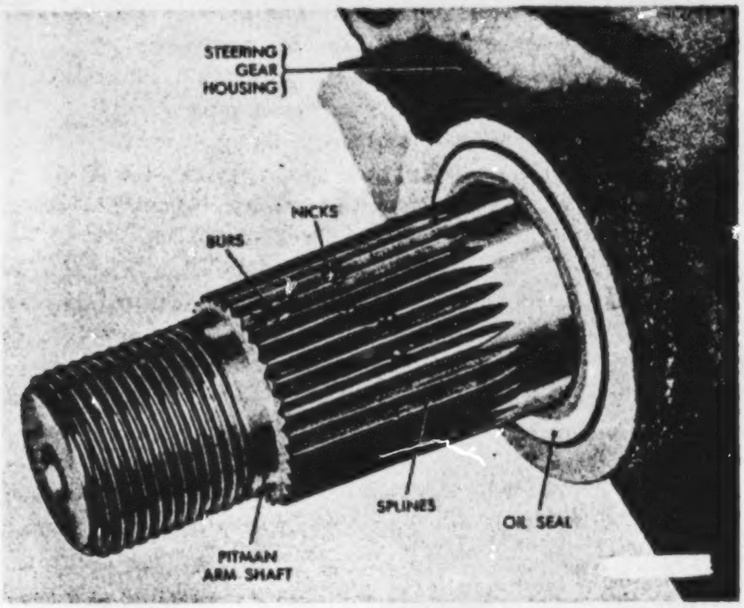
c. If the pitman arm has to be replaced, you should follow these procedures:



(1) First, remove the nut holding the pitman arm on the pitman arm shaft. Then, using a puller, pull the arm off the pitman arm shaft.

(2) Next, remove the ball socket parts on the pitman arm end of the drag link. Then remove the pitman arm from the drag link.

(3) Once the pitman arm is removed, inspect the threads and splines on the pitman arm shaft. If the threads or splines are not serviceable, the steering gear assembly must be replaced. If the pitman arm shaft has no nicks, burs, or other damage and is serviceable, you should prepare to install the replacement pitman arm.



(4) The steering gear must be positioned properly before the pitman arm is installed. To do this, turn the steering wheel to the center of its travel or midposition. You should remember from a previous lesson that the midposition is also called the high point. Once the steering is on the high point, install the pitman arm. When properly installed, the pitman arm ball should be directly below the pitman arm shaft. In other words, the arm should hang straight down.

(5) Next, install the drag link and adjust the ball socket spring tension as previously outlined in this lesson.

(6) The front wheels should be pointing straight ahead when the steering is on the high point. If the wheels are not straight ahead the pitman arm could be installed wrong. If the pitman arm is installed properly, check the drag link and the pitman arm. If either is bent, the steering will not be on high point when the wheels are straight ahead.

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d. As indicated earlier, the 2-1/2-ton truck uses one tie rod. The tie rod has two tie rod ends - one on each end of the tie rod. The center section of the tube type (hollow) tie rod is threaded in each end. One end has left-hand threads and the other end has right-hand threads. The entire center section of the tie rod therefore acts as a toe-in adjusting sleeve. It has the same function as the short adjusting sleeve on the 1/4-ton truck M151. The 2-1/2-ton sleeve is split on each end so that the sleeve can be clamped to the tie rod end. It is not split from end to end like the 1/4-ton truck sleeve. The tie rod or tie rod ends are replaced using the exact same procedures used on the 1/4-ton truck.

e. You should now see that repair and replacement of the 2-1/2-ton steering linkage are similar to the 1/4-ton truck. Next, let's see what can be done to aline the front wheels on this truck.

7. FRONT-WHEEL ALINEMENT. Alinement of the front wheels on the 2-1/2-ton truck is limited to one adjustment, toe-in. Due to the front-wheel drive, caster and camber are built into the axle. There is, therefore, no adjustment made to caster or camber by any maintenance personnel. The toe-in adjustment can be made at organizational maintenance level, so let's go over the procedures.

a. Like the 1/4-ton truck and any other wheeled vehicle, check the steering system condition before the toe-in is checked.

(1) Check the wheel bearings, steering knuckles, and tie rod ends for excessive play. If the steering knuckles are loose on the axle housing, notify your support maintenance unit. If the wheel bearings are loose, adjust the bearings to remove the play. If any looseness is found in the tie rod ends, replace the tie rod end. Don't forget to check the tire pressure so that the toe-in gage will work right.

(2) If all steering parts are serviceable, you are ready to check or measure the toe-in. You can use the same type gage used on the 1/4-ton truck to measure the toe-in. Make sure the wheels are straight ahead before you install the gage. Position it in front of the wheels and zero the gage. Then move the gage to the rear of the wheels and take a reading on the gage.

(3) The toe-in for M34-series 2-1/2-ton trucks with single rear wheels should be between 1/16 and 1/8 inch. The toe-in for M35-series 2-1/2-ton trucks with dual wheels should be between 1/16 and 3/16 inch. If the toe-in is incorrect, unlock both ends of the tie rod or adjustable sleeve at the tie rod ends. Then turn the center section of the tie rod to lengthen or shorten the tie rod. This is the same basic procedure used on the 1/4-ton truck.

(4) The 2-1/2-ton truck has only one tie rod. This means the tie rod adjustment cannot be used to center the steering wheel. You learned in an earlier lesson that the steering wheel can be mounted in many positions. This feature is used to center the steering wheel on the 2-1/2-ton truck.

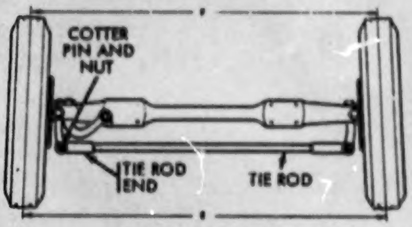
b. If a toe-in gage is not available, you can measure the toe-in by using another method. This method is sometimes even more accurate than the first method. Let's see how it's done.

(1) Jack up the front wheels, one at a time, until they clear the floor or ground. Hold a pencil against the center of the tire tread. Make sure the pencil does not move to either side, and then turn the wheel by hand.

(2) Continue turning the wheel until the pencil line is made around the entire tire. If the pencil is held as it should be, the lines will meet when the wheel is turned completely around. Make sure you mark or scribe both tires in this manner.

(3) Next, make sure the wheels are pointing straight ahead and then release and remove the jack.

(4) Now all that has to be done is to measure the distance between the pencil lines with a tape measure. Start at the front of the wheels and measure the distance (F in the accompanying illustration). The measurement should be taken about halfway up the tire or on a line with the housing axle.



E MINUS F = TOE-IN ORD E21647

(5) Then move to the rear of the wheels and measure the pencil lines (E in the illustration above). Make sure the measurement is taken at the same height (on a line with the axle housing). This measurement at the rear of the wheels should be 1/16 to 1/8 inch greater than the front measurement for M34-series 2-1/2-ton trucks. It should be between 1/16 to 3/16 inch greater for M35-series 2-1/2-ton trucks.

(6) For example, let's say you are checking the toe-in on a 2-1/2-ton truck M35A2. This is one of the M35-series trucks. The measurement taken in front of the wheels is found to be 72 inches. This means the measurement taken at the rear of the wheels should be between 72-1/16 inches and 72-3/16 inches. For this example, we will say the pencil lines at the rear of the wheels were 72-1/8 inches apart. The front wheels, therefore, have 72-1/8 minus 72 or 1/8 inch toe-in. According to the toe-in specifications (1/16 to 3/16 inch), this toe-in is satisfactory.

(7) This method of measuring toe-in is more accurate than the first method if a wheel is bent. This is because the pencil line you make is straight even if the wheel is bent.

(8) If you have trouble seeing the pencil line on some tires, there is a way to help this problem. Hold white chalk against the same area on the tire. Turn the wheel by hand and whiten this area of the tire. Then hold the pencil in the same area and make the pencil line. It will be easy to see using this method.

c. This last method of measuring toe-in can be used on many wheeled vehicles. To get the most accurate measurement, the lines should always be measured at about half the height of the tires. This point, as indicated above, is on a line with the axle housing or center of the wheel hub.

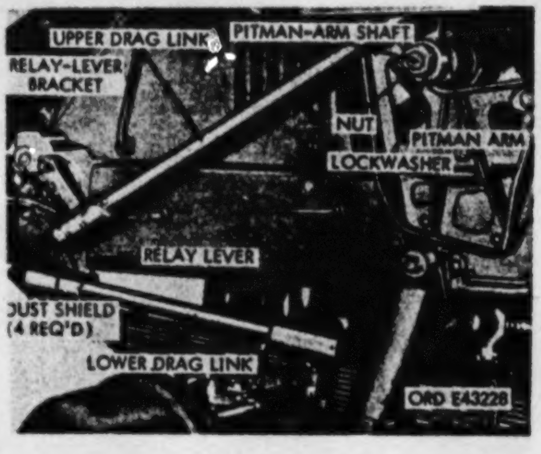
d. The 2-1/2-ton trucks have quite a bit more working clearance under the vehicle than the 1/4-ton trucks. This additional room helps when you are inspecting, repairing, adjusting, or replacing steering linkage components.

SECTION III. 5-TON TRUCKS

8. GENERAL. Some of the 5-ton truck steering linkage is similar to the steering linkage used on the 2-1/2-ton truck. Therefore, only the difference will be covered in this part of the lesson. Let's first take a look at the 5-ton linkage and see how it differs.

a. The steering gear on the 5-ton truck is mounted on the left frame rail just like the 2-1/2-ton. The 5-ton truck steering gear, however, is mounted farther back on the frame rail. Due to this mounting location, more linkage is needed to connect the steering gear to the front wheels.

b. The major difference in the 5-ton and 2-1/2-ton truck steering linkage is the drag links. If you look at the accompanying illustration you can see how the drag links look. Notice that there are two drag links - an upper one and a lower one. The upper drag link connects the steering gear pitman arm to the relay lever. The relay lever has two ball-type connections. The upper drag link connects to the upper ball. One end of the lower drag link connects to the lower ball on the relay lever. The other end of the lower drag link connects to the steering arm on the axle.



c. The steering gear on the 5-ton truck is power assisted. You learned in an earlier lesson that it is called power steering. The power steering unit has a pitman arm like the mechanical steering gear. When the front wheels are straight ahead, the pitman arm points about straight up. If you look at the illustration in the above paragraph you can see how the upper drag link is angled. This is necessary to connect to the top-mounted pitman arm.

d. The rest of the steering linkage is basically the same as the 2-1/2-ton truck steering linkage. The tie rod ends, however, are different. On the 5-ton truck the tie rod ends can be disassembled and separate parts replaced.

e. We have just learned how to maintain the 2-1/2-ton truck steering linkage. Now let's learn the maintenance procedures on the 5-ton truck steering linkage parts that are different than the 2-1/2-ton linkage. Let's start with inspection procedures.

9. INSPECTION. Make a visual inspection of all steering linkage parts. Make sure none of the parts are missing, bent, or broken. Use the same inspection procedures used on the 1/4-ton and 2-1/2-ton truck steering linkages. Make sure you also check for loose mounting bolts on the power steering unit and the relay lever bracket.

10. COMPONENT REPAIR AND REPLACEMENT. Let's learn how to repair or replace any parts that differ from the 2-1/2-ton truck. We will start with the pitman arm.

a. The 5-ton truck pitman arm has the same job and is mounted basically the same as the 2-1/2-ton truck. The main difference is that it is mounted pointing up rather than pointing down like the 2-1/2-ton truck.

(1) There is no repair to the pitman arm; however, it can be replaced. The upper drag link is connected to the pitman arm ball with an adjustable ball socket. It is removed following the procedures used on the 2-1/2-ton truck drag link.

(2) The pitman arm is also removed from the pitman arm shaft in the same manner as used on the 2-1/2-ton truck arm. Make sure the puller is attached properly before the puller screw is tightened.

(3) Like the 2-1/2-ton truck, the steering must be positioned right before the pitman arm is installed. The steering wheel must be in the center of its travel. The front wheels must also be straight ahead if the drag link is already attached to the pitman arm as outlined in the following paragraph.

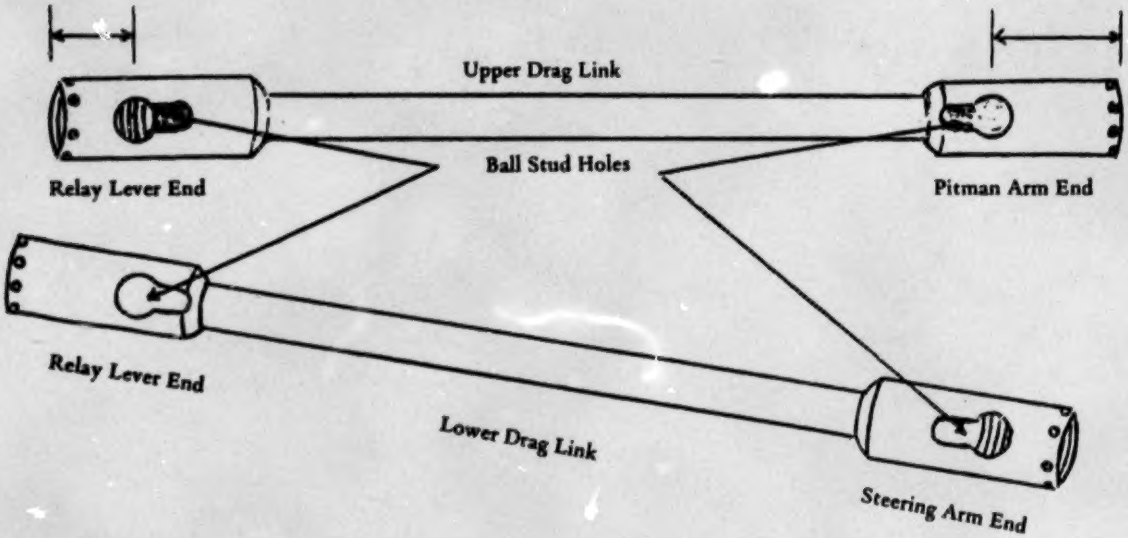
(4) First, connect the replacement pitman arm to the rear end of the upper drag link. The adjustment on the ball socket is slightly different than the 2-1/2-ton truck. Tighten the adjusting plug until it stops. Then back it up until the slots aline with the first cotter pin hole in the tube. Make sure you install a new cotter pin.

(5) Next, with the front wheels still straight ahead and the steering wheel centered, install the pitman arm on the pitman arm shaft. It should be pointing upward when the front wheels are straight ahead. Make sure you tighten the nut securely.

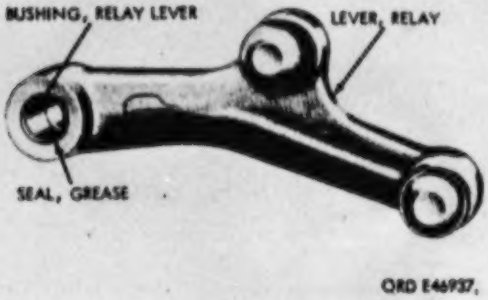
b. The drag links are both removed and installed in the same manner. There is one precaution. The drag links can be installed with either end to the front of the truck. One way is right and one way is wrong. If you look at the drag links you will find that the ball stud opening on one end is farther from the end of that drag link end. Both ball stud holes are therefore not equal distances from the drag link ends.

(1) To install the upper drag link properly, the end with the ball stud hole closer to it connects to the relay lever. The end with the ball stud hole farther from the end connects to the pitman arm.

(2) To install the lower drag link properly, the end with the ball stud closer to it connects to the steering arm on the front axle. The end with the ball stud hole farther from it connects to the relay lever. You can see an example of the difference in location of ball stud holes in the accompanying illustration.



d. The relay lever was not included in the 2-1/2-ton steering linkage, so let's take a look at it.

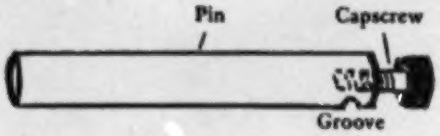


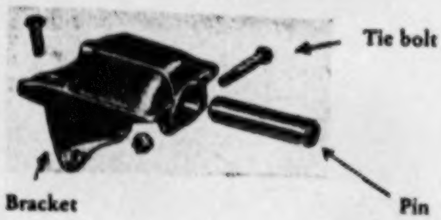
ORD E46937.

(1) The relay lever and bracket are mounted on the frame forward of the steering gear. This is about the same location as the steering gear on the 2-1/2-ton truck. The relay lever is mounted on a pin. The lever has bushings and seals pressed into each side of the lever. The bushings act as bearings between the lever and the pin. If the bushings become worn, the lever will tend to twist in the bracket as the steering wheel is turned back and forth. Worn bushings mean the cover must be replaced.

(2) To replace the lever, disconnect both drag links at the relay lever ball studs. Then remove the lubrication (grease) fitting from the end of the pin.

(3) Next, thread a 3/8-inch National fine (NF) thread capscrew in the grease fitting hole threads FINGER TIGHT. Do not tighten with a wrench or the threads will be damaged. Then remove the tie bolt and nut that clamp the bracket to the pin. Hold the relay lever and pull the pin from the bracket by pulling on the capscrew.





(4) Inspect the pin. If it is worn where the bushings ride, replace the pin.

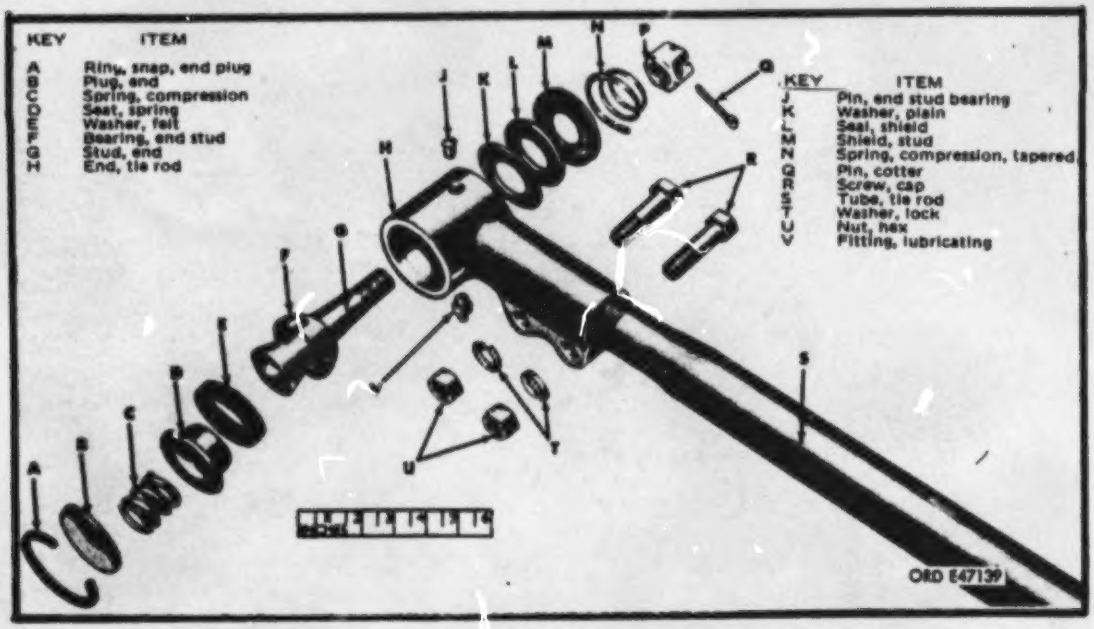
(5) Before the relay lever is replaced, lubricate the bushings and seals with GAA (grease, automotive and artillery). Then hold the relay lever in place in the bracket and install the pin. When installing the pin, make sure that the groove across the pin is on the bottom. When the pin is properly in place, the tie bolt will fit in the groove.

(6) Once the pin is in place, install the tie bolt and nut. Then install the upper drag link on the upper ball stud. Install the lower drag link on the lower ball stud. Adjust the ball socket as outlined earlier in this lesson.

(7) Remove the temporarily installed puller capscrew and install the grease fitting. Lubricate the pin and bushings with GAA.

e. The tie rod ends on the 5-ton truck can be repaired. This is not possible on the 1/4-ton or 2-1/2-ton trucks. The 5-ton truck tie rod ends are normally only replaced at organizational maintenance and repaired at a support maintenance shop. Just in case you are assigned at a support maintenance shop sometime, let's see what the inside of the tie rod end looks like.

(1) You can see an exploded view of the 5-ton truck tie rod end in the accompanying illustration. Notice that the stud (G) rides in a bearing (F). The stud is held tight in the bearing by a spring (C) and spring seat (D). The tie rod end inner parts are held in place by a snapring (A) and end plug (B).


KEY ITEM
A Ring, snap, end plug
B Plug, end
C Spring, compression
D Seat, spring
E Washer, felt
F Bearing, end stud
G Stud, end
H End, tie rod
KEY ITEM
J Pin, end stud bearing
K Washer, plain
L Seal, shield
M Shield, stud
N Spring, compression, tapered
Q Pin, cotter
R Screw, cap
S Tube, tie rod
T Washer, lock
U Nut, hex
V Fitting, lubricating
A
B
C
D
E
F
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ORD E47139

(2) The parts needed for this tie rod end come in a repair kit. If you are eventually assigned at support maintenance, you may be required to repair a tie rod end.

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(3) While assigned at organizational maintenance level you will replace the entire tie rod end. You should notice the two bolts (capscrews, R) in the illustration on page 29. They are used to clamp the tie rod end onto the tie rod. If you remember the 1/4-ton truck tie rod, the tie rod sleeve clamped onto the tie rod end. Keeping this in mind, replacement of the tie rod end is otherwise the same as the 1/4-ton truck. Once a tie rod end is replaced, the toe-in must be measured and adjusted, if necessary. Toe-in is covered in the following paragraph.

11. FRONT WHEEL ALINEMENT. Due to the construction of the 5-ton truck front axle, toe-in is the only alinement that can be adjusted. This, you learned, was also true with the 2-1/2-ton truck. Toe-in adjustment is made using either of the same methods used on the 2-1/2-ton truck. When adjusted correctly, the 5-ton truck front wheels should be toed-in between 1/16 and 3/16 inch. Like the 2-1/2-ton truck, the tie rod is turned to make the adjustment.

SECTION IV. TROUBLESHOOTING STEERING SYSTEMS

12. GENERAL. During this subcourse you have learned how both mechanical and power steerings work. You have also learned how to maintain the steering linkage and how to maintain some steering gears. Steering systems, like other mechanical systems, can develop some problems or troubles. As a wheeled vehicle mechanic you will be working with some of these troubles. You must first find what is causing the trouble. Then you adjust, repair, replace, or do whatever it takes to correct the trouble. This maintenance action, as you have already learned, is called troubleshooting. In an earlier lesson you learned of some unwanted steering factors that affected steering. Let's see how some of those factors affect the entire mechanical steering systems of wheeled vehicles.

13. HARD STEERING. Let's say that during a road test of a 2-1/2-ton truck, you find it hard to steer. The steering wheel is hard to turn or seems to bind.

a. The first step in locating this trouble is a visual inspection. Make sure all parts are in place. Make sure the steering linkage is not bent. Make sure the tire pressure is not low.

b. Don't overlook the possibility of the lack of lubrication. Check the lubricant level in the steering gear and the front axle. Lubricate all steering linkage points to include the steering knuckles. Then try the steering to see if the lubrication helped it. Another cause of hard or binding steering is a misalined steering housing and jacket. A good way to inspect for this condition is to loosen the mounting bolts and then retighten them. This allows the steering assembly to aline itself.

c. If the trouble still exists, the next best step is to find out if it is in the steering gear or the linkage and steering knuckles (pivots). On the 2-1/2-ton and 5-ton trucks, this can be done by first disconnecting the steering gear from the drag link at the pitman arm. On the 1/4-ton truck, disconnect it at the pitman arm and the rod between the pitman arm and the idler arm.

(1) Next, turn the steering wheel to see if it still turns hard. If it does, the trouble is some place in the steering gear. It can't be in the linkage or steering knuckles (pivots) because they are disconnected.

(2) Let's say that on a 2-1/2-ton truck the steering wheel turned free with the linkage disconnected. The trouble must be somewhere in the linkage or steering knuckles. Do not start removing parts yet. Find out where the trouble lies.

(3) Make sure the rear end of the drag link is free on the steering arm ball. If it is, disconnect one tie rod end. Then jack up both front wheels. Try turning each wheel back and forth as it would move when the steering wheel is turned. If one wheel turns or swings hard, the steering knuckle is probably binding. This is a job for your support maintenance unit.

(4) If both steering knuckles are free, check the tie rod ends to make sure the ball studs can be turned in their sockets.

d. By using this step-by-step method to check for the hard steering, you will not do more work than is necessary to locate the trouble. If the trouble is in the steering gear, it can possibly be adjusted to correct the trouble. You are authorized to adjust the 2-1/2-ton truck steering gear at organizational level. If adjustment does not help, the steering must be replaced.

14. TRUCK PULLS TO ONE SIDE. Let's say an operator complains that his 1/4-ton truck M151 is pulling to the right. There are many possible causes for this problem. Some causes can be corrected easily. Other causes require a lot of work. The mechanic generally starts with the more probable causes first. This is especially true if the more probable cause is easy to correct. For example, a bent frame or frame/body combination (M151) can make a vehicle pull to one side. A low tire can also make a vehicle pull to one side. There is little doubt that the mechanic would first look for a low tire. Let's go over some of the possible causes and corrective actions for this trouble - pulling to one side.

a. Have you ever experienced a tire slowly going flat while you are driving along? In fact, the reason you suspected you had a low tire is that the vehicle started pulling to one side. Check the tire pressure of all the tires on a vehicle that pulls to one side. Make sure the vehicle is loaded correctly. This can also cause the vehicle to pull in one direction.

b. Check for loose or missing parts. On the 1/4-ton truck M151 the shims could have fallen out of the front suspension. If you find this condition, notify your support maintenance unit. When the shims fall out, the front end or wheel alinement can change enough to cause the vehicle to pull to one side.

(1) Any parts in a front axle that shift or move can cause this pulling condition. For example, on a 2-1/2-ton truck, if the front axle U-bolts come loose, the axle can shear off the spring center bolt head. This allows the axle to slide, generally to the rear. If the spring is not mounted properly on the axle, the vehicle will generally pull to one side.

(2) Sometimes if parts are loose, the vehicle will pull first to one side and then to the other side. This condition is generally referred to as erratic steering or loose steering rather than pulling to one side.

c. If a vehicle pulls to one side, don't forget about lubrication. If the steering parts are binding due to lack of lubrication, the front wheels may hang up pointing to one side of the center. This would have a pulling effect on the vehicle.

d. Don't forget to look for bent parts or parts that are adjusted too tight. This will also cause a pulling condition. Bent parts include the entire front axle housing.

e. Dragging brakes or binding wheel bearings can also cause a vehicle to pull to one side. You can jack up one wheel at a time to check for this trouble.

15. ERRATIC STEERING. Earlier in this subcourse you learned that steering could develop a number of troubles. For example, it could work as it should on smooth, level road; however, when the road is banked to the right the vehicle pulls to the right. Where the road banks to the left, the vehicle pulls to the left. When these conditions exist, we say the steering is erratic. If something is erratic it does not continue to do the same thing. It does first one thing and then another.

a. Erratic steering can be due to loose parts. The loose parts prevent the operator from having full control at all times. For this reason loose steering and erratic steering often have the same causes.

b. Another cause for erratic steering is incorrect front-wheel alinement. This is especially true on the 1/4-ton truck with adjustable caster and camber. If nothing else can be found causing the erratic steering, notify your support maintenance unit of the trouble. They are authorized to check and adjust the front-wheel alinement. 199

c. If the vehicle is loaded, make sure that the load is not moving about. This will cause a very definite erratic steering condition.

d. Erratic steering is sometimes referred to as wandering, because the symptoms are basically the same for both problems.

16. SHIMMY. This is one of the most common problems found in wheeled vehicle steering systems. It is generally caused by a bent wheel or something about the wheel and tire that is not in balance. If the bent or out of balance condition is not bad, no shimmy is generally noticeable on the steering wheel. However, if any steering parts are loose, a slight shimmy can cause a serious steering problem. The loose parts allow the shimmy to become worse. As a wheeled vehicle mechanic, you can often stop most shimmy by repairing, adjusting, or replacing loose parts.

a. Shimmy can also become worse if the front-end alinement is not correct. This, we have learned, with the exception of toe-in, is a job for support maintenance personnel.

b. Shimmy can also be quite noticeable if the shock absorbers are worn or weak. Shock absorbers can be replaced by organizational maintenance personnel.

c. Another cause of noticeable shimmy is tires that are worn uneven. This is especially true if the tires are cupped out. The only cure for a cupped-out tire is to replace it.

d. When you are looking for loose parts, don't forget to include the wheel bearings. You will have to jack up each wheel and check the adjustment to see if the wheel bearings are loose or tight.

17. LOOSE STEERING. When there is excessive play in the steering wheel, the vehicle is said to have loose steering. Loose steering causes the operator to continuously fight the steering wheel.

a. Too much play in the steering system can be traced to many parts. A good way to localize the trouble is to first turn the steering wheel to the midposition or high point. Then have someone rock the steering wheel back and forth. The steering wheel movement should be just the distance of the free play or until resistance is felt in each direction. Look at the linkage, starting at the pitman arm shaft. If the pitman arm shaft does not move when the steering wheel is turned, the excessive play is in the steering gear. If the pitman arm shaft moves, follow this linkage until you find where the excessive play is located.

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b. Don't forget to look for loose mounting bolts. This includes the front axle-to-spring U-bolts and the spring hanger bolts or rivets. Remember any loose components can cause loose steering.

c. You should remember that a loose steering gear assembly can cause a vehicle to oversteer. The vehicle turns shorter than the operator wants it to turn. This unwanted steering factor is called drive.

d. In reviewing the various troubles you will be troubleshooting, one thing is evident: many of the troubles or unwanted factors can have the same cause. Do not start repairing or replacing parts until you are sure where all the trouble lies. Sometimes you will find that one loose part is causing more than one trouble. Other times you may find you have to repair or replace more than one part to correct one trouble or problem.

SECTION V. CONCLUSION

18. SUMMARY. Steering linkages don't really have too many parts, but they are mighty important ones. Probably a good inspection is one of the most important maintenance actions you can perform on these parts. As a wheeled vehicle mechanic, you are authorized to repair or replace most wheeled vehicle linkage parts. During this lesson you have learned the procedures for inspecting, adjusting, and repairing the steering linkage of 1/4-ton, 2-1/2-ton, and 5-ton trucks. These linkages are representative of steering linkages on most wheeled vehicles. You also learned of some of the problems found in wheeled vehicle steering linkages. Armed with the information gained in this lesson, you should have little trouble troubleshooting steering systems, to include power steering linkage.

19. PRACTICE TASKS. The appendix of this lesson contains a list of tasks associated with steering linkage maintenance. They are representative of the tasks you will be required to perform as a wheeled vehicle mechanic. Perform all the tasks listed. Be sure you are under the supervision of an officer, NCO, or specialist who is qualified in the MOS when you practice the tasks. If you find you are having difficulty in certain tasks, restudy the appropriate training material and practice the tasks until you become proficient in each one.

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Note. - Questions 86 through 93 apply to the 1/4-ton truck M151.

86. Which maintenance step should be performed first on the steering linkage?

   a. Inspection of the entire steering system
   b. Repair or replacement of all defective parts
   c. Adjustment of the front wheel toe-in

87. Which statement is true in reference to inspecting the steering linkage?

   a. Lubricate all steering components before an inspection is made
   b. A good method to find looseness is to jack up both front wheels and tires, and then rock the steering wheel
   c. If the steering gear is found to have too much slack, support maintenance should be notified

88. What action should a wheeled vehicle mechanic take if he finds a bent tie rod on the left side?

   a. Notify direct support
   b. Straighten out the bend
   c. Replace the bent part

89. Which steering linkage condition can cause the right end of the pitman arm-to-idler arm rod to move up and down excessively?

   a. Worn idler arm bracket bushing
   b. Loose right spindle arm
   c. Stripped pitman arm spline

90. What is used to retain the idler arm bushing in the pitman arm-to-idler arm rod?

   a. Threads
   b. Snapring
   c. Coil spring

91. What must be replaced if the tie rod end that connects to the pitman arm is worn excessively in the ball socket?

    a. Pitman arm-to-idler arm rod
    b. Left tie rod assembly
    c. Pitman arm assembly

92. How far should a replacement tie rod end be threaded into the adjustment sleeve?

    a. Until it bottoms against the opposite tie rod end
    b. Equal distance of opposite tie rod end
    c. Use up all threads on the replacement tie rod end

93. You have just adjusted the toe-in on a 1/4-ton truck to the correct specifications. After driving the vehicle forward a few feet, you again check the toe-in and find it to be wrong. Which condition can cause this problem?

    a. Bent tie rod
    b. Loose wheel bearings
    c. Worn steering roller

Note. - Questions 94 through 98 apply to the 2-1/2-ton truck M35A2.

94. The drag link ball sockets are adjusted properly when the adjusting plug is turned until it bottoms and then

    a. torqued to 30 - 35 lb-ft.
    b. turned back one full turn.
    c. turned back to the first or second cotter pin hole.

95. How can a worn drag link ball be detected once the ball socket is adjusted?

    a. Steering wheel is hard to turn on each side of high point
    b. Ball socket is too loose when front wheels are not pointing straight ahead
    c. Steering wheel turns too hard when the high point is crossed

96. In which direction does a properly installed pitman arm point when the steering gear is in the midposition?

    a. Downward
    b. Upward
    c. Forward

97. Which is the correct method to change the amount of toe-in? 203

a. Disconnect and turn one tie rod end in the tie rod
b. Turn the entire center section of the tie rod
c. Remove the tie rod temporarily and turn each tie rod end in the same direction an equal amount

98. Measuring between two pencil lines will provide a more accurate toe-in measurement than when using a toe-in gage if the vehicle has

a. loose wheel bearings.
b. bent wheels.
c. worn tie rod ends.

Note. - Questions 99 through 102 apply to the 5-ton truck.

99. When assembling the steering linkage, the rear end of the lower drag link connects to the ball stud on the

a. relay lever.
b. pitman arm.
c. steering arm.

100. Which statement is true in reference to the maintenance of steering gear components?

a. The relay arm ball studs can be replaced without replacing the entire relay lever
b. The upper drag link is positioned properly when the end with the closer ball stud hole is connected to the relay lever
c. A flat or worn pitman arm ball stud can be repaired properly by filing down the side until the ball is again round

101. What fits in the groove that is cut across the outer end of the relay lever pin?

a. Half moon key
b. Tie bolt
c. Snapring

102. Which toe-in measurement, in inches, is within the acceptable range for the 5-ton truck?

a. 1/32
b. 1/8
c. 1/4

Note. - Questions 103 through 105 apply to troubleshooting of wheeled vehicle steering systems.

103. During an inspection of a 2-1/2-ton truck you find that both front tires have only half enough air pressure. If these tires are left in this condition they will cause an unwanted driving condition called

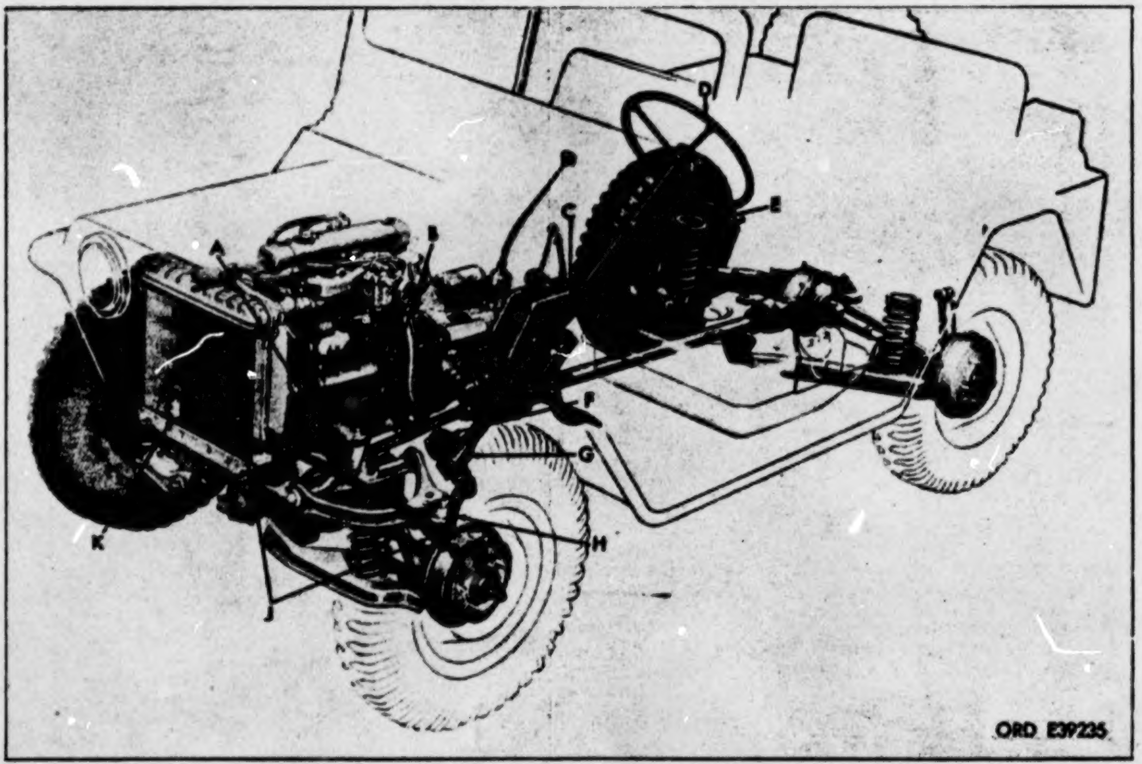
   a. shimmy.
   b. loose steering.
   c. hard steering.

104. As a wheeled vehicle mechanic, you are trying to locate the cause of a 1/4-ton truck M151 pulling to the right. An inspection of the vehicle shows the caster and camber adjusting shims are missing on one side of the suspension due to a loose bolt. Which action should you take to correct this problem?

   a. Notify support maintenance of the condition
   b. Install new shims and tighten the bolts securely
   c. Tighten the loose bolt and see if the vehicle still pulls

105. A 2-1/2-ton cargo truck operator complains that his truck pulls first to one side and then to the other side. An inspection of the truck shows all of the following things wrong. Which one is most likely causing the operator's problem?

   a. Load of five drums of oil free to roll in cargo body
   b. Both front tires severely cupped out
   c. Shock absorbers leaking on both front wheels



Key	Item	Key	Item
A	Idler arm mounting bracket	F	Adjusting screw
B	Pitman arm-to-idler arm rod	G	Steering gear assembly
C	Steering column	H	Steering pitman arm
D	Steering wheel	J	Spindle arm tie rod assembly
E	Steering column-to-dash panel bracket	K	Spindle arm

Foldout illustration No 1. Steering linkage components, 1/4-ton truck M151.

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EXERCISE RESPONSE LIST

SUBCOURSE 63B207

WHEELED VEHICLE STEERING SYSTEMS

OCTOBER 1975

DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL
ABERDEEN PROVING GROUND, MARYLAND

RESPONSE NUMBER	RESPONSE*
100	Para 9b
101	Para 7
103	Para 10
104	Para 2
106	Para 4a
109	CORRECT. There is less clearance between the worm and roller at the midposition of the steering wheel's travel.
110	Para 7a through 7c
112	CORRECT. Providing that the two items compared are of the same design, such as gear or vane.
113	Para 15c
116	CORRECT. But, remember, that the teeth of the sector consist of a double-toothed roller.
117	Para 12b
119	CORRECT. This shape reduces the chances for air being pumped into the system caused by the tip of the suction line becoming uncovered due to sloshing of the liquid.
122	Para 14b(2)
123	Para 4a
124	Para 2
127	CORRECT. This lengthens or shortens the tie rod--depending on the direction it is turned. One direction increases the toe-in, whereas the other direction makes the toe-in less.
129	Para 13a

*If your response is not listed CORRECT, refer to the indicated paragraph for the proper answer.

131 CORRECT. This is the exact middle of the recommended toe-in range. The wheels can also have 1/16 inch less or 1/16 inch more toe-in and still be within the recommended toe-in range.

133 Para 3a

134 Para 3a(4)

136 Para 3e

138 Para 9

141 CORRECT. Being mounted in this position allows the engine to operate the pump using V-belts.

143 CORRECT. This is directly determined by how fast the pump is being driven.

145 Para 2a through 2c

147 CORRECT. This type of steering gear is commonly used on larger trucks and often contains two studs that engage the cam to make it stronger.

150 Para 2b

152 Para 7

154 CORRECT. It's the only safe way to solve the problem. With human lives involved, we can't take a chance on questionable steering parts.

156 Para 5b

159 CORRECT. Providing there are no bent parts, it will be in this position any time the front wheels are pointing straight ahead. This is true even if it is improperly installed on the shaft; however, the steering gear would not work as it should unless it is installed properly.

161 CORRECT. The valve is concentric with the input shaft and located on the steering gear.

164 Para 3b

166 Para 10

167 Para 5

170 Para 3a(8)

173	Para 9a(6)
175	CORRECT. You should first determine the condition of the overall system.
177	CORRECT. The symbol for this part is used in hydraulic circuit diagrams just like the symbol for a common ground is used in electrical circuit diagrams.
178	Para 12
179	Para 9b(4)
181	Para 6a and 6b
184	Para 4
186	Para 10b
188	Para 13
191	CORRECT. You did not have full turning control of the vehicle. This is a dangerous situation and the problem should be corrected at once.
192	CORRECT. The wheel spindle will be pointed downward on its outer end, thus placing the center of the tire more nearly under this bearing.
194	CORRECT. Adjusting shims are located between this item and the steering gear housing.
195	Para 4
197	CORRECT. To have complete control of maximum pressure, however, the valve must be capable of bypassing the entire output of the supply pump.
199	Para 10c
200	CORRECT. Flow through the valve in another position is shown by just imagining that another section of the symbol is placed between the lines.
202	Para 3g
204	Para 3
205	Para 2d

206	Para 6
207	Para 8e
210	Para 5d
212	Para 7b
213	Para 11
215	Para 11b
218	CORRECT. This diagram usually consists of an outline of the vehicle showing the parts in the exact spots where they are located.
220	Para 8b(1)
223	CORRECT. Remember, the pressure per square inch is distributed the same throughout a confined liquid.
225	CORRECT. A vehicle with this part worn and a right wheel out of balance can develop a dangerous shimmy condition. This condition can also cause extreme tire wear.
227	Para 5
228	Para 5c
231	Para 8a through 8c
233	Para 14d(4)
235	CORRECT. This item is extended hydraulically and retracted by spring pressure or the weight of the work.
236	Para 11
239	Para 5
241	Para 5
242	Para 2b
243	Para 4
245	Para 13b
247	Para 8b

248	Para 8a
250	CORRECT. There are many other causes for this condition--one of them being lack of lubrication. When you find this condition, use the method described in the lesson to isolate the trouble.
253	Para 3
256	CORRECT. This causes an automatic steering effect that is in the direction the vehicle tends to go. That is, in the direction of forward momentum, with a crosswind, and down off the road crown.
259	CORRECT. This pushes the wheels farther apart at the rear and brings them closer together in the front.
260	CORRECT. The highest pressure is obtained when the wheel is held against the steering stop, but it should only be held there momentarily.
262	Para 6a
264	Para 12b
266	CORRECT. By using this method both ends will always be threaded in the same distance. This gives equal strength in the threads of each tie rod end.
268	Para 8c
271	Para 14d
274	Para 11
276	CORRECT. The liquid generally consists of a blend of different substances instead of just oil by itself.
277	Para 6
278	Para 5b
279	Para 15c
281	CORRECT. You are not authorized to make any adjustments except toe-in on this vehicle. Tighten the loose bolts and make a temporary toe-in adjustment before the vehicle is driven.

282	Para 14d
284	Para 3b(4) and 5c
286	Para 15c
288	Para 8a
289	CORRECT. Both valves are check valves which allow the liquid to flow in one direction only.
290	Para 7e
292	Para 3a
293	Para 6
295	Para 7
296	Para 9b(3)
298	Para 14a
299	Para 2b
301	CORRECT. If the pin is positioned properly, the retaining device should pass completely through the bracket with a light push from the fingers.
304	Para 5
307	Para 3a(9)
309	CORRECT. Remember, however, that the piston movements are computed from the piston areas--not their diameters.
311	Para 4k
313	Para 8b(1)
316	Para 8
318	Para 15c
320	CORRECT. This symbol shows that the only purpose of the line is to drain or return liquid to the reservoir.
323	CORRECT. A decision will be made at this level as to what should be done.

324 Para 15c

326 Para 3a

328 Para 10b

330 CORRECT. This is so steel balls will fit in the threads.

332 Para 6d

333 Para 5

336 Para 12

339 CORRECT. Due to slight differences in mounting and adjustments on some trucks, the power piston may travel far enough in the full left turn position to expose a port in the cylinder wall, thus allowing the escape of hydraulic pressure. The piece of iron limits the piston travel.

341 Para 12b

342 CORRECT. In comparing a hydraulic system to an electrical system, this unit will be comparable to the battery.

344 Para 9b

347 Para 13a

349 CORRECT. This gives the wheels negative caster and will also cause the vehicle to tend to steer up the road crown.

350 CORRECT. Remember to take the reading with the spring scale hooked to the spoke at the rim of the steering wheel.

352 Para 3e

356 Para 12c

358 CORRECT. Remember, the adjustment must be locked in place with a locknut.

360 Para 14a(3)

362 CORRECT. Liquid flowing through this valve, regardless of the amount it is opened, wears against the entire sealing surface evenly.

363 Para 3b

365 CORRECT. This causes the hydraulic steering to act just like a turning effort was being applied to the steering wheel.

367 Para 3b(4) and 5c

369 Para 14

371 CORRECT. Replacing this part also provides new mounting points for two tie rod end ball studs and an idler arm bushing.

372 Para 5d

374 Para 6c

375 Para 10

376 CORRECT. This is information that the mechanic must know in order to troubleshoot the system.

378 CORRECT. Mechanical advantage is also gained mechanically by the leverage of the jack handle.

379 CORRECT. This makes it impossible to mount the pitman arm pointed in the wrong direction.

382 CORRECT. It will supply liquid flow under pressure to the system any time a condition exists that lowers the main line pressure.

385 Para 3a(8)

387 CORRECT. Most of the wear occurs when the wheels are straight ahead. Therefore, when the joint is adjusted in this position, as it should be, it will be too tight when the wheels are turned away from straight ahead.

389 Para 7

390 CORRECT. If the relief valve is a separate component it will have three lines connected to it: incoming and outgoing high-pressure lines and a relief line to the reservoir.

391 Para 14

392 CORRECT. The two parts are the steering arm and wheel spindle. On a turn the angle formed by these items causes the inside wheel to pivot more than the outside wheel.

393 CORRECT. Remember, the shims come in various thicknesses so the adjustment can be accurately made.

394 CORRECT. This steering gear contains a bearing mounted roller that meshes with the threads of the worm.

396 Para 7g and 9

397 CORRECT. If the problem is not real bad and the steering parts are tight, it may not be noticeable on some vehicles. However, in time the steering will loosen up due to this condition.

400 CORRECT. They are right-hand while the ones inside are left-hand. The right-hand ones are very coarse and have a self-cutting feature to help during installation of a new part.

402 Para 7

403 CORRECT. By disconnecting this item at the pitman arm, the load is removed from the gearbox so any slight drag can be felt when making the adjustment.

405 CORRECT. This level will assure complete filling of the hydraulic system and also allow for any oil expansion in the system.

407 Para 2a through 2c

408 Para 15c

409 Para 9

410 Para 7b

412 Para 2

415 CORRECT. There is a seal at each end of the worm shaft and another at the outer end of the pitman arm shaft.

416 Para 3a

417 CORRECT. This provides the same leverage when turning either to the right or left.

420 Para 7e

421 Para 4

422 Para 9

423 CORRECT. In this steering gear the worm is called a cam and the sector a lever.

425 CORRECT. The wires to this item pass under the steering gear shaft and must be removed in order to move the wiring harness out of the way before removing the steering gear.

426 Para 5 and 15

427 CORRECT. This valve can be quickly changed from one extreme to the other because of its simple design.

429 Para 7g and 9

431 Para 13

432 Para 9b(1) and (2)

434 Para 2b

437 CORRECT. Actually, this part is only compared to about 1/6 of a nut.

440 Para 14a(3)

442 CORRECT. The changing of vehicle loads and twisting of the vehicle over rough ground can leave this assembly out of alinement.

444 CORRECT. However, the front wheels should point straight ahead and the steering wheel be in midposition before installation.

446 Para 3g(6)

448 CORRECT. This is shown by the arrow inside the rectangle being out of line with the connecting lines.

451 Para 8b

452 Para 14

454 CORRECT. This eliminates any binding and, due to the spring inside, still maintains a joint with no slack or free play.

457 Para 12c

459 Para 11

460 Para 13b

463 Para 7e and 7f

465 Para 13

468 Para 3a(2)

471 CORRECT. The farther away the tire contact is moved from the steering knuckle pivot, the greater the road shock transmitted. This is because the wheel, tire, and spindle act as a lever; and the longer the lever, the greater the force sent to the suspension and steering linkage.

474 Para 3e

477 Para 8c

480 Para 14b

482 Para 11b

483 CORRECT. This is because the liquid pushes on twice as much area in piston B as it does in piston A.

485 Para 6

486 CORRECT. This system permits each front wheel to pivot without moving the front axle.

488 Para 2

490 Para 7

491 CORRECT. The piston rod pushes directly on one end of this item providing a power assist, while mechanical force supplied by the driver is applied to its opposite end.

492 CORRECT These items extend through the center of the wheel hub and the wheels revolve around them.

493	Para 3
496	Para 4b(2)
497	Para 3a(4)
498	Para 4k
500	Para 3a
501	Para 2
502	CORRECT. This would have the same effect as worn linkage parts between the pitman arm shaft and front wheels. This type condition allows the distance between the front wheels to change, which, therefore, changes the toe-in.
504	Para 10f
505	CORRECT. This does not prevent the nut from being removed at a later date.
508	CORRECT. This permits the mechanic to install it in the correct position even if some of the other parts are slightly out of line or bent.
510	Para 14
512	Para 14b
513	Para 3g(6)
516	Para 4
518	Para 6a and 6b
520	CORRECT. This retainer must be removed before the horn button can be pulled from the steering wheel.
521	CORRECT. This is one reason for keeping the liquid at the proper level.
522	Para 2b
523	Para 5
524	Para 11
526	Para 14d(4)
527	Para 5

529	Para 10
531	CORRECT. Remember, the steering linkage must be disconnected from the pitman arm when making this adjustment.
533	Para 3b
535	Para 3g
536	CORRECT. Liquids can furnish a solid connection between two remote cylinders because of this characteristic.
537	Para 11
539	Para 4b(2)
541	Para 2b
545	CORRECT. Be sure that the hollowed out (concave) side of this part is facing the ball stud once the link is installed.
547	Para 11
549	Para 5d
551	CORRECT. This way the compression springs will be on the correct side of the ball, and there will also be the correct amount of clearance between the forward ends of the drag links.
553	Para 8c
555	Para 3a(9)
557	Para 6d
559	Para 9a(6)
561	CORRECT. Equal distribution of weight is important if the vehicle is to steer correctly. If the load shifts to one side, the vehicle will probably pull to that side. Always make sure the load is secured before moving the vehicle.
562	CORRECT. It is closed by a combination of reverse flow and spring pressure or gravity.
563	Para 9b(4)

565 CORRECT. This pressure test gage is a component of a set that is designed for the task and is available at support maintenance.

567 Para 14

570 Para 8c

572 CORRECT. The angles for these two alinement factors are determined from the same viewpoint and both are measured in degrees so that they can be easily combined. A front wheel alinement specialist often uses the included angle to find out if the wheel spindle is bent.

573 Para 9b(1) and (2)

575 CORRECT. This maintenance function on this particular vehicle is the responsibility of a higher category of maintenance. On some wheeled vehicles you are authorized to check the adjustments; however, actual repair is still made at a higher level.

577 CORRECT. The drag link end of this part swings in an arc to move the steering linkage back and forth in a straight line.

578 Para 8a through 8c

579 Para 8

580 Para 2d

581 Para 12b

582 Para 2

584 CORRECT. This alinement factor is spoken of in degrees and is the angle formed by two imaginary straight lines--one through the center of the steering knuckle pivots and the other straight up and down.

587 CORRECT. Make sure that once the ball socket is properly adjusted a cotter pin is installed through the drag link end to prevent the adjusting plug from backing out.

590 Para 5b

591 CORRECT. The thrust bearings at the ends of the cam are spring-loaded so that some movement is allowed by compressing a spring when a turning effort is applied to the steering wheel.

594 CORRECT. Actually, this item is used to move the sector closer to or farther away from the worm.

595 Para 3

597 CORRECT. Vehicles with a front axle have one of these parts while those with independent suspension have two of them.

600 Para 14b(2)

603 Para 3a(1)(c)

605 Para 6c

607 Para 13

608 Para 5c

612 CORRECT. This part, however, provides rotary movement only. If straight line movement is desired, a cylinder is used.

614 Para 10c

615 Para 10f

617 CORRECT. If the steering arms point to the rear they are angled inward in the straight-ahead position. This causes the spindles to travel different segments of an arc on turns, which pivots the inner wheel more than the outer wheel.

619 CORRECT. The lines you are measuring are straight regardless of this condition. This method is generally used in commercial shops when toe-in must be set to close tolerances.

621 Para 3a(1)(c)

624 CORRECT. But, remember, it could also be caused by a defective steering gear and defective steering knuckle pivots.

627 CORRECT. This is an undesirable effect of this alinement factor.

628 Para 5 and 15

629	Para 4
630	Para 7e and f
631	Para 5b
634	CORRECT. That is because this effect causes the front wheels to try to return to the straight-ahead position after a turn.
635	Para 9
636	CORRECT. Liquid under pressure is entering the opposite end of the cylinder.
637	CORRECT. This is because sliding friction is replaced by rolling friction.
638	Para 8
639	Para 11
642	Para 2
643	Para 9b(3)
644	Para 6a
647	Para 6
648	Para 8c
651	Para 3b
657	Para 3
661	Para 8
662	Para 3
665	CORRECT. Two belts from the engine accessory drive rotate the double pulley to drive the pump.
669	Para 3a(2)
672	Para 3e
674	CORRECT. You must know just what the system is supposed to do and why each part is needed before you can tell if the system is operating properly, and, if not, which part is not doing its job.

677	Para 6
679	Para 14a
682	Para 14
684	Para 2
685	Para 11
688	CORRECT. Although you may be tempted to discard and replace only the felt pads, the dust shields are also discarded and new ones installed.
690	Para 7a through c
691	Para 3a
693	Para 11
694	CORRECT. The tips of the black triangles are pointed inward to show that oil is forced into the unit. Two triangles show that the unit will operate in two directions.
696	Para 5d
699	CORRECT. This offsets problems caused by uneven wear on the worm threads.

ANSWER SHEET

FOR STUDENT USE ONLY - DO NOT RETURN

	a	b	c		a	b	c		a	b	c		a	b	c		a	b	c
1.	104	501	538	41.	437	523	333	81.	246	405	460	121.	625	348	615	161.	428	613	114
2.	223	667	566	42.	348	638	274	82.	380	440	624	122.	484	255	399	162.	201	552	443
3.	421	308	243	43.	277	394	647	83.	600	365	122	123.	217	698	436	163.	509	373	660
4.	241	483	527	44.	539	486	689	84.	233	528	339	124.	334	503	139	164.	180	481	230
5.	375	166	612	45.	113	408	392	85.	565	282	271	125.	593	388	291	165.	357	272	564
6.	690	110	427	46.	622	387	299	86.	176	684	488	126.	111	650	331	166.	686	386	174
7.	582	290	420	47.	191	642	412	87.	434	160	576	127.	633	252	479	167.	343	161	606
8.	630	197	463	48.	358	682	263	88.	661	383	164	128.	216	438	528	168.	120	519	495
9.	579	143	661	49.	600	379	416	89.	226	474	672	129.	411	198	671	169.	628	246	314
10.	647	686	342	50.	116	483	204	90.	400	136	352	130.	558	169	388	170.	487	652	203
11.	289	578	231	51.	164	415	533	91.	371	535	202	131.	366	697	276	171.	286	433	540
12.	635	408	235	52.	629	196	520	92.	613	298	446	132.	144	467	656	172.	618	166	361
13.	429	386	538	53.	311	606	498	93.	106	654	543	133.	478	502	123	173.	473	653	249
14.	103	112	629	54.	167	238	323	94.	644	282	484	134.	602	268	460	174.	211	586	486
15.	119	336	178	55.	304	442	227	95.	387	518	181	135.	229	303	598	175.	182	351	661
16.	610	276	452	56.	631	360	590	96.	189	374	606	136.	168	441	306	176.	308	406	588
17.	236	362	524	57.	677	208	425	97.	557	127	332	137.	472	680	125	177.	538	265	105
18.	101	400	362	58.	389	402	147	98.	410	619	212	138.	369	157	576	178.	445	187	64
19.	521	381	309	59.	316	638	403	99.	247	451	587	139.	534	390	244	179.	153	542	31
20.	628	378	428	60.	194	583	288	100.	329	561	198	140.	675	221	401	180.	234	666	46
21.	486	124	582	61.	393	570	477	101.	199	301	614	141.	287	589	606	181.	670	263	560
22.	641	492	242	62.	294	367	109	102.	683	131	488	142.	364	695	189	182.	302	430	148
23.	326	133	587	63.	207	545	648	103.	431	607	250	143.	641	297	489	183.	574	317	240
24.	293	486	637	64.	422	138	606	104.	281	480	512	144.	163	596	386	184.	185	348	684
25.	248	330	288	65.	615	504	417	105.	561	288	318	145.	546	322	287	185.	326	663	281
26.	152	296	423	66.	145	487	218	106.	116	567	238	146.	226	449	514	186.	622	176	466
27.	298	591	643	67.	680	285	376	107.	601	222	419	147.	418	139	609	187.	692	269	618
28.	573	380	432	68.	621	177	603	108.	414	199	608	148.	506	395	196	188.	208	517	327
29.	537	213	256	69.	468	668	320	109.	385	611	172	149.	294	604	406	189.	686	413	107
30.	192	264	117	70.	134	487	684	110.	687	439	329	150.	424	158	353	190.	377	673	132
31.	581	471	341	71.	385	448	170	111.	140	381	589	151.	645	219	548	191.	135	319	461
32.	279	617	324	72.	200	555	307	112.	394	687	193	152.	128	583	254	192.	683	186	370
33.	601	577	292	73.	674	184	516	113.	610	118	556	153.	321	453	676	193.	494	251	525
34.	289	679	298	74.	567	290	682	114.	148	447	209	154.	171	364	620	194.	544	469	232
35.	347	572	129	75.	228	606	181	115.	462	335	623	155.	683	237	464	195.	267	530	649
36.	186	694	278	76.	372	141	698	116.	336	696	404	156.	435	692	146	196.	668	263	455
37.	179	583	401	77.	549	666	210	117.	108	224	300	157.	560	102	337	197.	315	160	632
38.	466	684	188	78.	444	220	313	118.	568	664	142	158.	310	532	270	198.	137	511	340
39.	216	634	482	79.	698	558	173	119.	306	121	640	159.	214	475	571	199.	568	363	290
40.	487	627	384	80.	100	344	531	120.	183	470	273	160.	678	162	348	200.	478	689	128

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US ARMY ORDNANCE CENTER AND SCHOOL
CORRESPONDENCE/OJT COURSE

EXAMINATION VERSION 1

Ordnance Subcourse No 63B207. . . Wheeled Vehicle Steering Systems

Credit Hours . . . . One

Objective . . . . To test the student's overall knowledge of material covered in this subcourse.

Suggestions . . . . Before starting this examination, review all lessons studied in this subcourse.

Texts . . . . Attached Memorandums

Materials Required . . . . None

(Do not send these pages in—use the answer sheet provided for recording and mailing your solution.)

OS 63B207, E-P1
October 1975

MULTIPLE CHOICE

(See instructions on answer sheet provided)

Note. - Questions 1 through 3 apply to figure 1.

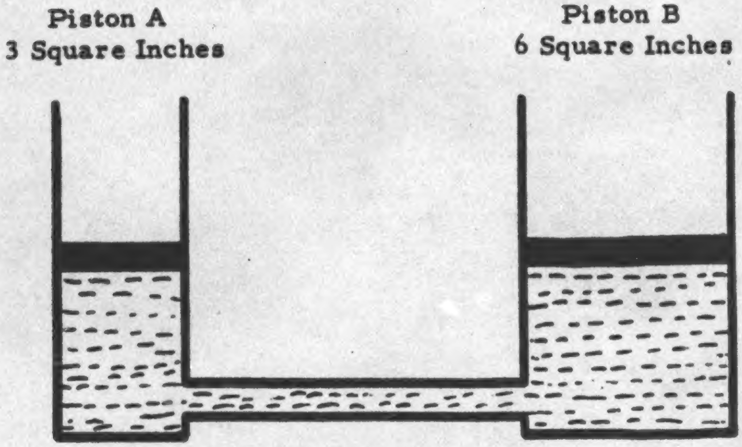
Piston A
3 Square Inches
Piston B
6 Square Inches

Figure 1.

1. What is the mechanical advantage ratio of the hydraulic system shown?

   a. 2:1
   b. 3:1
   c. 6:1
   d. 9:1

2. How many pounds of force will be pushing upward on piston B if a 3-pound weight is placed on piston A?

   a. 27
   b. 18
   c. 9
   d. 6

3. How many inches will piston A move if piston B is pushed down 1 inch?

   a. 4
   b. 3
   c. 2
   d. 1

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4. What action should the organizational mechanic take when an inspection reveals that the steering gear is binding on a 1/4-ton truck M151?

   a. Replace the steering gear
   b. Notify support maintenance
   c. Adjust the steering gear
   d. Install new worm and sector shaft bearings

5. On which truck must the engine be removed before removing the steering gear?

   a. 5-ton with a gasoline engine
   b. 2-1/2-ton with a gasoline engine
   c. 5-ton with a Mack diesel engine
   d. 2-1/2-ton with a multifuel engine

6. What steering factor is measured in inches?

   a. Toe-out
   b. Caster
   c. Toe-in
   d. Camber

7. What type of diagram is the best aid to the mechanic when troubleshooting a hydraulic system?

   a. Block
   b. Cutaway
   c. Graphical
   d. Pictorial

8. What is being adjusted in figure 2?

   a. Backlash
   b. Cam bearings
   c. Control valve
   d. Column alinement

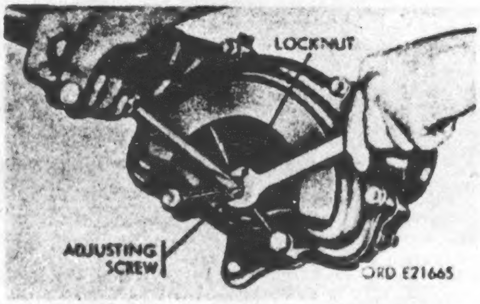
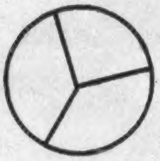


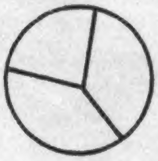
Figure 2.

9. With the front wheels positioned properly, how should the steering wheel be positioned to install it on the steering gear shaft of the 2-1/2- or 5-ton truck?

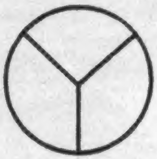
a.



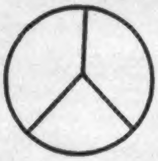
b.



c.



d.



Note. - Questions 10 through 12 apply to figure 3 which is an exposed view of the HP 70 power steering gear.

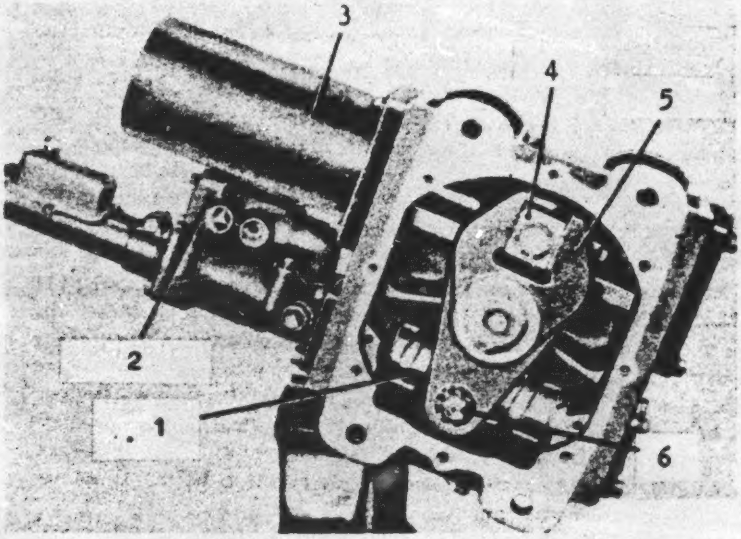


Figure 3.

10. What item converts the rotating motion of the steering wheel to a back-and-forth motion?

a. 1
b. 2
c. 4
d. 6

11. **What item meters the flow of oil to and from the power cylinder?**

- **a.** **4**
- **b.** **3**
- **c.** **2**
- **d.** **1**

12. **What item converts hydraulic pressure to mechanical force for turning the wheels?**

- **a.** **2**
- **b.** **3**
- **c.** **4**
- **d.** **6**

13. **When will a slight oil leak in the power steering pressure hose be easiest to locate?**

- **a.** **After the vehicle has sat for several hours without running so the oil is cold**
- **b.** **Immediately after a road test when the oil is hot**
- **c.** **When the steering wheel is held against the steering stop with the engine running**
- **d.** **When the steering control valve is in the neutral position with the engine running**

14. **What is caused by an improperly adjusted steering control valve on the 5-ton truck?**

- **a.** **Pulling to one side**
- **b.** **Uneven tire wear**
- **c.** **Shimmy of front wheels**
- **d.** **Weaving back and forth**

15. **What is the likely cause of steering drive?**

- **a.** **Unbalanced wheels**
- **b.** **Loose steering gear mounting bolts**
- **c.** **Pitted steering gear worm**
- **d.** **Misalined column jacket**

16. What should be replaced if the power steering relief valve is defective on a 5-ton truck equipped with a Mack diesel engine?

    a. Steering gear
    b. Hydraulic pump
    c. Control valve
    d. Power cylinder

17. What is the lowest category of maintenance authorized to adjust the steering gear on a 2-1/2-ton truck?

    a. Organizational
    b. Direct support
    c. General support
    d. Depot

Note. - Questions 18 through 21 apply to figure 4 which is a schematic diagram of the HP 70 power steering hydraulic system.

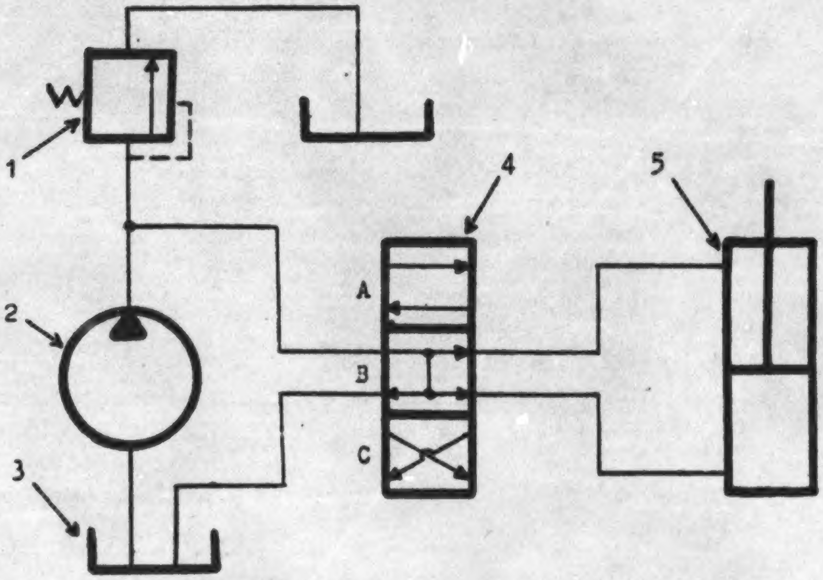


Figure 4.

18. What item is most likely to be at fault if the hydraulic pressure is too high?

    a. 1
    b. 2
    c. 4
    d. 5

19. What condition will allow liquid to flow freely from the pump to the reservoir?

    a. Vent line disconnected
    b. Cylinder fully extended
    c. Control valve in neutral
    d. Relief valve in normal position

20. To what part does liquid flow after flowing through the relief valve?

    a. Pump
    b. Reservoir
    c. Control valve
    d. Power cylinder

21. What occurs when the control valve is shifted to position A?

    a. Cylinder extends
    b. Relief valve opens
    c. Cylinder retracts
    d. Relief valve closes

22. The relay lever of the steering linkage on the 5-ton truck is secured to the relay lever bracket on the frame with a pin. If the relay lever must be removed, what is used to pull the pin?

    a. Capscrew
    b. Puller
    c. Brass drift
    d. Hammer

23. What construction feature of the drag link used on 2-1/2- and 5-ton trucks can be used to identify the front end of the drag link?

    a. Location of the ball stud opening
    b. Right-hand and left-hand threads at the ends
    c. Size of the ball seat opening
    d. Angle of the bend at each end

24. What statement is true concerning the drag link adjustment of the 2-1/2- and 5-ton trucks?

    a. Lock the adjusting plug when it is screwed in tight
    b. Screw the adjusting plug in tight and then back it out 1/2 turn or less
    c. Turn the steering wheel in both directions to free the ball and then lock the adjusting plug
    d. Tighten the adjusting plug until a slight drag can be felt while turning the steering wheel

25. What is the proper procedure for decreasing the cam end play of the steering gear on the 2-1/2-ton truck?

    a. Remove shims from between the gear housing and upper cover
    b. Replace the steering gear bearings
    c. Turn the adjusting screw in the side cover clockwise
    d. Tighten the adjusting plug until it bottoms

26. When removing the steering wheel on the 2-1/2-ton M35A2 truck, how is the puller attached to the steering wheel?

    a. Hub of puller is bolted directly to the hub of the steering wheel
    b. Hub of puller is bolted to an adapter plate under the steering wheel hub
    c. Hooks of puller are hooked to an adapter ring under the steering wheel spokes
    d. Hooks of puller are hooked under the hub of the steering wheel

27. What must be drained when replacing the power steering cylinder on a 5-ton truck with a HF-64 power steering system?

    a. Hoses
    b. Steering pump
    c. Steering gear
    d. Control valve

Note. - Questions 28 through 31 apply to figure 5. It is a diagram of the steering system for the 1-1/4-ton truck M715.

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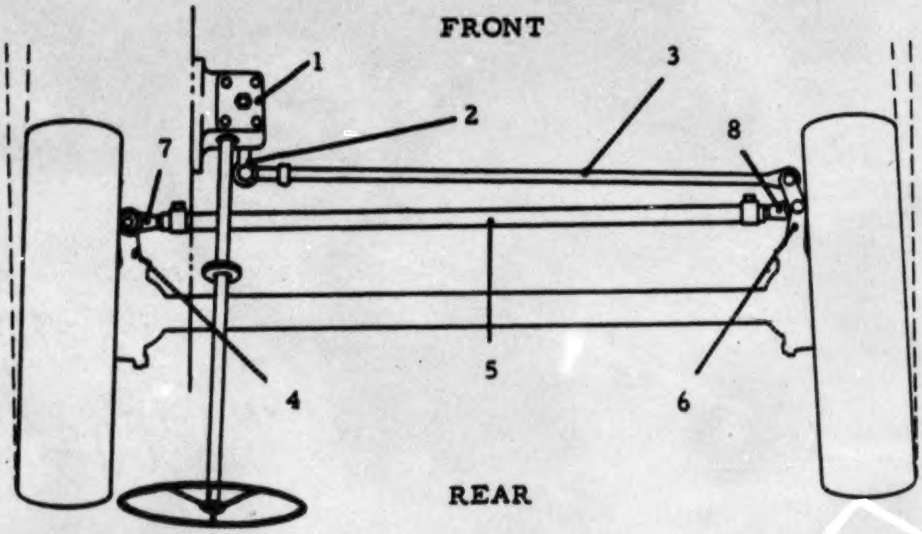

Figure 5.

28. What item converts the output of the steering gear to a motion that will force the wheels right or left?

    a. 1
    b. 2
    c. 3
    d. 6

29. What is done to increase toe-in?

    a. Lengthen item 3
    b. Shorten item 3
    c. Lengthen item 5
    d. Shorten item 5

30. What alinement factor will be affected if item 4 is bent?

    a. Caster
    b. Camber
    c. Toe-out
    d. Kingpin inclination

31. What part, if worn, will cause too much slack between the steering wheel and the left front wheel but will not cause slack at the right front wheel?

    a. 8
    b. 3
    c. 2
    d. 1

32. The toe-in must be adjusted after replacing which steering linkage part on the 5-ton truck?

    a. Lower drag link
    b. Relay lever
    c. Tie rod end
    d. Pitman arm

33. Which steering linkage part is turned clockwise (left-hand threads) when removing it from a 1/4-ton truck M151?

    a. Drag link end nut
    b. Steering arm
    c. Adjusting sleeve clamp bolt
    d. Idler arm

34. What should be done if the front wheels of a 1/4-ton truck M151 are pointed slightly to one side when the steering gear is at midposition?

    a. Reposition the steering wheel on the steering shaft splines
    b. Shorten one tie rod and lengthen the other one
    c. Remove the pitman arm and install it in a different position
    d. Adjust the worm bearing end play and the worm and sector backlash

35. The toe-in gage must be between the wheels and at what location in relation to the front axle when reading the amount of toe-in?

    a. Top
    b. Bottom
    c. Front
    d. Rear

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* U.S. GOVERNMENT PRINTING OFFICE: 1976--738-734